



iMAST

Institute for Manufacturing and Sustainment Technologies

IN THIS ISSUE

Feature Article

Focus on Repair Technologies

Navy Valve Actuator Repair Using Cold Spray

Institute Notes

Calendar of Events

DIRECTOR'S CORNER

The iMAST team appreciates the opportunity to serve and nothing gives us more satisfaction than the successful implementation of a new repair capability or manufacturing tool/technique. This edition's feature article is about a technology that successfully transitioned into mainstream industry but further seeks DoN applications as recently as 2010. Cold Spray, also known as supersonic particle deposition or gas dynamic cold spray, has been successfully implemented at several Navy depots and shipyard. The list continues to grow. Dr. Tim Eden and his team have worked for several years to identify Cold Spray applications within our Navy sustainment enterprise as well as define the processes for various metal alloy substrates and the powder metals sprayed by the systems. If you have questions about Cold Spray, please don't hesitate to call us for additional information.



Timothy D. Bair

Continued on Page 2

Winter Assumes Helm of Office of Naval Research

Rear Admiral Mathias W. Winter recently assumed leadership of the Office of Naval Research, becoming the 25th Chief of Naval Research with concurrent flag responsibilities as Director, Innovation Technology Requirements, and Test & Evaluation (N84). Admiral Winter succeeds RADM Matthew Klunder, who has retired.

A 1984 graduate of the University of Notre Dame, Admiral Winter received his commission through the Naval Reserve Officers Training Corps. He was designated a Naval Flight Officer in 1985.

Admiral Winter served operational tours as an A-6E Intruder Bombardier/Navigator with Attack Squadrons 42, 85 and 34—making multiple deployments aboard aircraft carriers USS Saratoga (CV 60), USS America (CV 66), USS Dwight D. Eisenhower (CVN 69) and USS George Washington (CVN 73). Acquisition tours include assistant deputy program manager (DPM) for the Joint Standoff Weapon System; executive assistant to the Joint Strike Fighter (JSF) program director; chief engineer for JSF Integrated Flight and Propulsion Control; DPM for the Tactical Tomahawk All-Up-Round development program; chief of staff to the Program Executive Officer (PEO) for Tactical Aircraft Programs; and his major acquisition command tour as the Precision Strike Weapons (PMA-201) program manager.



Continued on Page 7



A U.S. Navy Manufacturing Technology Center of Excellence



**DIRECTOR, iMAST &
NAVY/MARINE CORPS REPAIR
TECHNOLOGIES**

Timothy D. Bair
(814) 863-3880 tdb14@arl.psu.edu

MATERIALS PROCESSING TECHNOLOGIES

Timothy J. Eden, Ph.D.
(814) 865-5880 tje1@arl.psu.edu

LASER PROCESSING TECHNOLOGIES

Richard P. Martukanitz, Ph.D.
(814) 863-7282 rxm44@arl.psu.edu

**COMPOSITES MATERIALS
TECHNOLOGIES**

Kevin L. Koudela, Ph.D.
(814) 863-4351 klk121@arl.psu.edu

MANUFACTURING SYSTEMS TECHNOLOGIES

Mark T. Trabant, Ph.D.
(814) 865-3608 mtt1@arl.psu.edu

**SYSTEMS OPERATIONS AND AUTOMATION/
COMPLEX SYSTEMS MONITORING**

Eddie C. Crow
(814) 863-9887 ecc1@arl.psu.edu

DRIVETRAIN TECHNOLOGIES

Nagesh Sonti, Ph.D.
(814) 865-6283 nxs7@arl.psu.edu

iMAST ADMINISTRATION and EDITOR

Gregory J. Johnson
(814) 865-8207 gjj1@arl.psu.edu

FINANCIAL COORDINATOR

Brenda E. Kephart
(814) 865-3264 bew3@arl.psu.edu

WORLD WIDE WEB

www.arl.psu.edu/imast.htm

NAVY PROGRAM MANAGER

Gregory D. Woods
gregory.woods1@navy.mil

©2015. The iMAST newsletter is published by the Institute for Manufacturing and Sustainment Technologies of the Applied Research Laboratory at Penn State, University Park, PA. iMAST is sponsored by the U.S. Navy Manufacturing Technology (ManTech) Program, Office of Naval Research, under Navy Contract N00024-12-D-6404. Any opinions, findings, conclusions, or recommendations expressed within are those of the authors and do not necessarily reflect the views of the U.S. Navy. Send mail list requests or address corrections to: iMAST Administrator, ARL Penn State, P.O. Box 30, State College, PA 16804-0030 or e-mail: bew3@arl.psu.edu. Parcel delivery address (UPS, FedEx, USPS): Rear, Research Building West, North Atherton Street, State College, PA 16804.

This publication is available
in alternative media on request.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to minorities, women, veterans, individuals with disabilities, and other protected groups. Nondiscrimination: <http://guru.psu.edu/policies/AD85.html>

U.Ed. ARL 15-24

DIRECTOR'S CORNER

I receive numerous questions about our parent organization, the Applied Research Laboratory at Penn State. One in particular is: How do we execute our mission as a DoD University Affiliated Research Center (UARC)? While I do not have sufficient space to completely outline our roles and responsibilities, let me briefly explain. UARC's are Office of Secretary of Defense (OSD) chartered. We are a DoD service-sponsored trusted agent organizations with assigned core competencies designed to supplement DoD capabilities with persistent expertise and basic research reach-back. ARL is the second largest of the 13 DoD sponsored UARC's. Our technical expertise and capabilities include Materials & Manufacturing, Fluids, Structural Mechanics & Acoustics, Undersea Weapons and Communication, Information & Navigation. You can dig deeper at our website: <http://www.arl.psu.edu/index.php>. As a DoD UARC, ARL works predominantly with DoD defense enterprises and the contractors who directly support them. As a Navy-sponsored UARC, we work more commonly with the Navy Systems Commands, the acquisition and operational program offices, as well as centers, labs, depots and shipyards.

Focusing further, iMAST is a matrix organization within ARL with a small permanent staff to support the center and access all ARL's expertise

as the individual projects require. iMAST supports the ONR ManTech program as one of its seven centers of excellence. ONR's priority for its investment is first acquisition cost reduction, focused mostly on the VCS, ORP, DDG, CVN, F-35 and CH-53K programs. Secondly, life cycle cost, or sustainment cost reduction, is focused on support for shipyards and depots. The latter is what we refer to as RepTech (Repair Technology).

The Cold Spray project discussed below is a RepTech project aimed at developing a repair processes for several different shipboard components. The common denominator for all four components was a high condemnation rate coupled with limited or no repair process previously authorized. This effort followed on the heels of a previous NAVAIR-focused component repair process that was highly successful. Pulling scrap metal out of the recycle bin and putting it back on line, in a full mission capable status is very satisfying. This represents substantial cost savings that otherwise would go towards costly replacement parts purchases.

Please contact us if you have questions or feedback on any of the topics noted.

Tim Bair

PROFILE



Timothy J. Eden holds Ph.D. and M.S. degrees in mechanical engineering from The Pennsylvania State University. He received a B.S. degree in mechanical engineering from the University of Utah. Dr. Eden is head of the Materials Processing Division within Penn State's Applied Research Laboratory. The Materials Processing Division includes the Advanced Coatings Department, the Metals and Ceramic Processing Department, and the High Pressure Test Facility.

Dr. Eden has been working in Cold Spray technologies for the past 16 years. Other areas of active research include high performance (ultra-high strength and high-temperature) aluminum alloys, thermal management systems, corrosion and wear wear-resistant coatings, materials characterization and testing, process improvement and optimization, functionally tailored and laminate materials, and consolidation processes for materials. Dr. Eden can be reached at (814) 865-5880, or by email at <tje@arl.psu.edu>.



Navy Valve Actuator Repair Using Cold Spray

by Timothy J. Eden, Ph.D.

Cold spray is a reduced temperature, supersonic thermal spray process increasingly being used to perform repairs on high value components. In this case, a valve actuator internal bore sealing surface was repaired on an aluminum 6061 hydraulic valve body using high pressure cold spray. Corrosion damage to non-critical surfaces was also repaired, allowing the part to be returned to service. The VRC Gen III high-pressure cold spray system was used to deposit gas atomized 6061 aluminum powder. The internal bore surfaces were approximately 100 mm in diameter with a depth of nearly 200 mm, and were sprayed using a 45-degree nozzle 65 mm in length. The minimum required adhesion strength on critical surfaces was 69 MPa. The average adhesion strength was 71.4 MPa, with glue failures on ASTM C633 bond test specimens. ARL Penn State, in conjunction with industry, academia and other DoD support organization have been exploiting this technology on behalf of the Navy, Marine Corps and Army. The following article addresses specific activity related to cold spray repair activities associated with Navy valve actuators.

Corrosion related maintenance and failures were estimated to cost the U.S. military over \$20 billion in 2004,¹ and have been rising steadily since that time. Atmospheric and subsequent localized corrosion damage results in decreased safety and increased operating costs. Any proposed repair methods should restore the damaged material without adversely affecting the base material, and ideally should not overheat the underlying substrate material so as not to induce large residual stresses or cause unnecessary artificial aging or other microstructural changes. Cold spray technology has already been shown to have numerous industrial applications,² as well as the potential to repair previously un-repairable components for the U.S. Navy.³ Present work investigates the potential

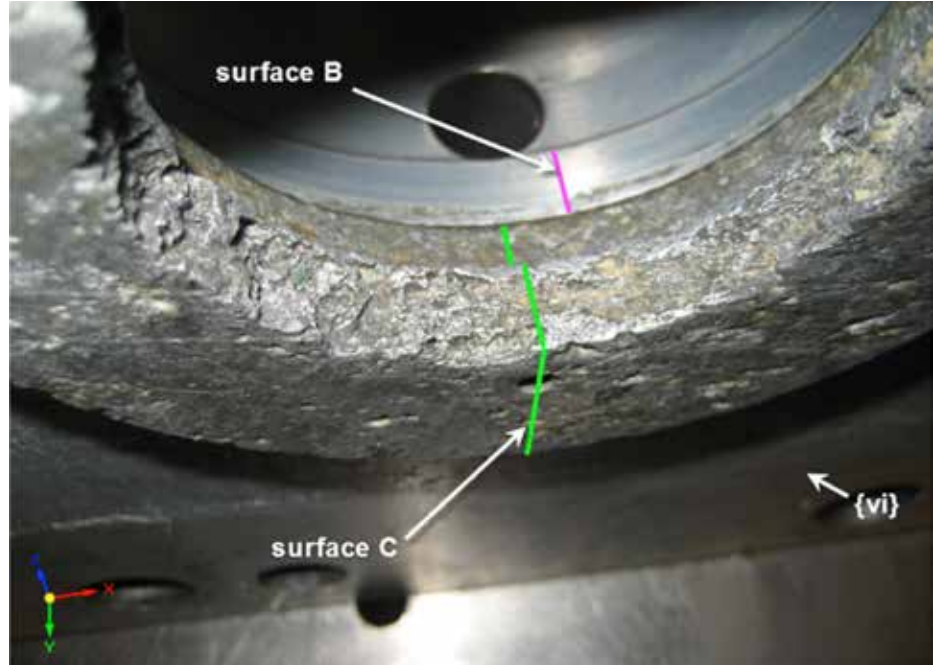


Figure 1. Close-up photo of seawater corrosion damage on the outboard portion and sealing surfaces on the valve actuator's internal bore.

application for reclaiming previously un-repairable aluminum valve actuator bodies for the U.S. Navy. The actuators have internal bore features as small as 89 mm. The repairs were performed using a VRC high pressure Cold Spray System with a small 45 degree nozzle developed by VRC Metal Systems and the South Dakota School of Mines and Technology in Rapid City, SD in partnership with the Army Research Lab, MOOG, and Penn State's Applied Research Lab. This project is being done in collaboration with Puget Sound Naval Shipyard and intermediate maintenance facility.

Cold spray (CS) was developed in the mid-1980s at the Institute of Theoretical and Applied Mechanics, Novosibirsk, Russia and was patented in 1990. CS is a low-cost and environmentally friendly process that presents a novel additive approach to applying powdered materials in a layer-by-layer fashion at relatively low temperatures, compared to other thermal spray processes.⁴ In the cold spray process, small (1-50 μm) metal particles

are accelerated towards a substrate at high velocity (300-1200 m/s [Mach 1-3.5]) by a supersonic jet of compressed gas. The particles form a coating on the substrate by means of ballistic impingement. The carrier gas (air, N₂, or He) is used at pressures as high as 69 bar and temperatures as high as 1100 °C, and is expanded to supersonic speeds through a converging diverging nozzle.

In this application, cold spray is used to repair both exfoliation and pitting corrosion damage to a part made from 6061 aluminum as seen in Figure 1. It is generally believed that exfoliation corrosion is intergranular in nature and propagates due to a galvanic interaction between the precipitates and the matrix. When the precipitates are noble and concentrated at the grain boundaries, then the attack occurs at the solute depleted regions around the precipitates and propagates rapidly into the material along those boundaries.⁵ Pitting corrosion is another common form of attack observed in 6061 aluminum components, particularly in a seawater environment.⁶

FEATURE ARTICLE

Continued from Page 3

Tungsten Inert Gas (TIG), Metal Inert Gas (MIG), and laser cladding of aluminum are possible options for repair of the aluminum actuator. These methods are able to produce strengths and porosities that would meet or exceed the repair requirements for the aluminum actuator in coupon type test samples. However, distortion of adjacent surfaces with limited space, tight tolerances, and numerous finished part features adjoining to the repair locations, as well as the knockdown in the heat affected zone of the substrate material, make those options unattractive. The internal bore with the critical mating surfaces has an internal diameter less than 102 mm. Laser cladding of internal bore surfaces is a new and growing technique. It has been proven to be effective at cladding the internal diameter of steel bores with nickel. However, at this time, all commercial process operations are being run without an inert atmosphere which would be required for optimal properties in aluminum cladding.

EXPERIMENTAL PROCEDURE

The actuator was repaired using a VRC Gen III high-pressure cold spray system (VRC Metal Systems, Rapid City, SD, USA), seen in Figure 2. 6061 Al coatings were produced via cold spray from commercially available gas-atomized 6061 Al powder (Valimet, Stockton, CA, USA), -325 mesh, deposited on a 6061 aluminum alloy substrate. Helium was used as the process gas to achieve high impact velocities between incident particles.



Figure 2. VRC Gen III cold spray system

The pressure and temperature of helium were maintained at 34.5 bar and 500°C at the heater exit, respectively. Deposition took place using a nozzle stand-off distance of 20 mm, 45° deposition angle, medium powder feed rate of approximately 10 g/min., and a nozzle traveling speed of 250 mm/s. Finally, total deposition thicknesses ranged from 2mm to 8mm. A picture of the setup is shown in Figure 3.



Figure 3. Experimental Setup to repair the valve actuator.

Prior to repair of the aluminum actuator, proof of concept testing was required to ensure that cold spray could achieve the level of properties needed for the repair. A mockup, which had the same internal bore geometry as the actuator, was repaired first. Tensile, ASTM C633 bond adhesion, and porosity testing results from the mockup were reviewed and approved prior to the repair of the aluminum actuator. Due to the stringent performance requirements, it had to be demonstrated that minimum coating properties were achieved through these tests before the repair of the aluminum actuator. Cold spray repair would be authorized.

RESULTS

A mockup of the actuator is shown in Figure 4. The purpose of the mockup was to determine the feasibility of repairing the critical surfaces of the aluminum actuator using cold spray. Figure 5 is an image of the final mockup after cold spray showing the most critical surfaces for parameter development. Dark spots in the micrograph represent porosity. The maximum allowable porosity in this zone is 5%. Applying a coating on this area proved to be challenging due to the sharp interface at the corner. The porosity in the initial mockup was as high as 16%. In order to achieve a more consistent coating, it was necessary to experiment with parameters, such

as approach angle and speed, to minimize porosity and defects in the inside bottom corner of the internal bore. Measurements were made using an area fraction analysis with Buehler Omnimet software. From the results, it can be seen that the cold spray coating was able to achieve an average of 3% porosity based on a total of 14 measurements from two locations. This result compares well with previously reported results, which produced cold spray coatings of 6061 aluminum using high pressure in the range of 2-3% porosity.⁷

Tensile testing was the second requirement for approval to repair the aluminum actuator. A solid block of Al-6061 was produced using the same incident angle between the cold spray gun and the substrate as would be used during deposition on the critical surfaces. From the deposited block of Al-6061, a set of four reduced size ASTM E8 type tensile specimens were removed using wire EDM. Two of the test specimens were tested internally and two were sent to the Navy for testing. The results showed that the strength of the cold spray material far exceeded the minimum requirement of 68.9 MPa for ASTM C633 bond strength, however, there were no minimum tensile values as a part of the qualification requirements.



Figure 4. Photo of the mockup used as a proof of concept for the aluminum actuator.



Figure 5. Micrograph showing the quality of the cold spray deposition in the bottom corner of the internal bore critical surface of the aluminum actuator mockup.

ASTM C633 bond testing was the final requirement for approval to repair the aluminum actuator. The incident angle between the cold spray gun and the substrate had to be the same as the incident angle during deposition on the critical surfaces. Figure 6 is an image of the cold spray depositions made for testing. The actual bond strength of the Al-6061 coating was higher than the reported average as all of the failure occurred as glue failures, not adhesive or cohesive failures of the coating, i.e. the CS layer exceeded the strength of the epoxy. From the results it can be seen that the cold spray depositions were able to meet the requirements for approval to repair the aluminum actuator.



Figure 6. Photo of the ASTM C633 bond test specimens deposited for proof of concept testing.

To provide more data to further qualify cold spray for the repair of the aluminum actuator, a series of bond tests were performed on the deposited mockup. Figure 7 shows the setup used to perform bond testing of the deposited mockup. From the image it can be seen that the mockup was sectioned and areas of the cold spray deposit were prepared for ASTM C633 type bond button testing. The results show that the cold spray depositions were able to meet the requirements for approval to repair the aluminum actuator.



Figure 7. Photo of the simulated C633 bond testing on the mockup.

Once the proof of concept testing was completed, approval was received to repair the aluminum actuator. The first actuator repair attempt failed due to poor bonding in the inside corner region near the bottom

of the internal bore (i.e. in the general area shown in Figure 5). The cold spray material was then machined off, and based on the lessons learned during the first failed repair attempt, a stringent process control document was prepared and followed during the next deposition process, which led to a successful repair on the second attempt. An image of the as-received aluminum actuator after re-machining in preparation for the repair is shown in Figure 8.

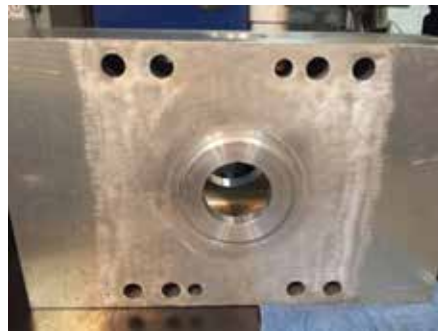


Figure 8. Photo of the as received aluminum actuator.

Post repair testing of sample coupons sprayed during the repair of the aluminum actuator was required to ensure that the cold spray clad applied to the repaired actuator had achieved the level of properties needed for the repair. Tensile testing, ASTM C633 bond testing, and porosity testing were performed. Tensile testing was the first requirement for approval to repair the aluminum actuator. As with the proof of concept testing, the incident angle between the cold spray gun and the substrate had to be the same as would be seen during the deposition of the critical surfaces. From a deposited block of cold spray clad, a set of four tensile specimens were removed. Two of the test specimens were tested internally and two were sent to the Navy for testing. After further process development, the results of the internal testing show that the strength of the cold spray deposited material exceeded the requirement set forth to get approval to repair the aluminum actuator. The results of the Navy testing were reported to NAVSEA and were accepted. Figures 9 and 10 show images of the aluminum actuator post deposition, showing the repair for comparison with the corroded surfaces shown in Figure 1.

ASTM C633 bond testing and porosity testing were the final requirements for approval to



Figure 9. Photo of the aluminum actuator internal bore repair.



Figure 10. Repaired external corrosion surfaces of the aluminum actuator post.

repair the aluminum actuator. As with the proof of concept testing, the incident angle between the cold spray gun and the substrate were the same as used on the critical surfaces. Optical porosity measurements were also performed on one of the ASTM C633 witness samples, which were provided with the repaired actuator (Table 1). The cold spray witness sample measured far less than the required 5% porosity on the critical surfaces, however, flat surfaces are expected to be lower than the complex internal corner surfaces, etc.

Field #	Field Area (μm)	Pore Area (μm)	%Porosity
1	689035	4537	0.66
2	696284	2805	0.40
3	691296	7213	1.04
4	734710	4298	0.59
5	702271	8620	1.23
6	743023	11371	1.53
7	761011	6050	0.80
8	774172	9026	1.17
9	827792	6719	0.81

Table 1. Shows the results of the optical porosity testing performed for repair qualification.

FEATURE ARTICLE

Continued from Page 5

Bond Strength	S1: 73 MPa - Glue failure
	S4: 78 MPa - Glue failure
	Average: 75.7 MPa

Table 2. Shows the results of the ASTM C633 bond testing for repair qualification.

Table 2 (above) shows the results from the ASTM C633 bond testing. Again, the cold spray depositions were able to meet the requirements for approval to repair the aluminum actuator, which was a minimum of 68.9 MPa.

After final deposition and measurements were completed the aluminum actuator was crated and sent out for post machining by the Navy, where post repair certification testing and final machining were performed. A photograph of the final machined actuator internal bore is shown in Figure 11. After machining, the valve body was functionally tested and the repaired actuator was cleared for installation.

CONCLUSIONS

A Navy Al-6061 hydraulic valve actuator was successfully repaired using high-pressure cold spray deposition. The repair demonstrated the ability of cold spray to successfully deposit Al-6061 on internal surface of relatively small diameter, deep bores. The repair process

development has shown the potential for even more challenging future applications as the strength of the cold spray deposited material was found to be in excess of 200 MPa as deposited. It is felt that through further development, even higher strengths will be achievable using high-pressure cold spray systems. This repair is now being offered commercially by MOOG, which demonstrates a full technology transition pathway from a university R&D laboratory in partnership with an equipment supplier to design and provide the necessary hardware for the repair, and an industrial service provider to fulfill future repair needs. This repair is expected to both provide a generous return-on-investment as a repair process, as well as to increase system availability by providing an alternative to the long lead times of new purchased parts.

ACKNOWLEDGMENT

The author would like to express appreciation for support of this effort by the Institute for Manufacturing and Sustainment Technologies (iMAST), an organization within The Pennsylvania State University's Applied Research Laboratory. iMAST is a U.S. Navy Manufacturing Technology (ManTech) Program Center of Excellence under contract

by the Office of Naval Research. The author would like to also acknowledge collaborations with Mr. Tom Stamey, Puget Sound Naval Shipyard and the Intermediate Maintenance Facility; Mr. Victor Champagne of the Army Research Laboratory; Professor Christian Widener and M. J. Carter of the South Dakota School of Mines; Mr. Rob Hrabec of VCR Metal Systems; and Mr. Ben Hoiland of Moog-Mid-America. Any opinions, findings, conclusions and recommendations expressed in the article are those of the author and do not necessarily reflect on the views of the U.S. Army or U.S. Navy.

REFERENCES

- 1 Gerhardus, H.K. "Cost of Corrosion in Military Equipment," NACE Corrosion 2004, Document IDNACE-04252, 28 March-1 April, New Orleans, Louisiana, 2004.
- 2 Gärtner, F., et al., The Cold Spray Process and Its Potential for Industrial Applications. Journal of Thermal Spray Technology, vol. 15, no. 2, pp. 223-232, 2006.
- 3 Champagne, V.K. "The Repair of Magnesium Rotorcraft Components by Cold Spray," Journal of Failure Analysis and Prevention, Vol. 8, No. 2, pp 164-175, April 2008.
- 4 Papyrin, A., Cold Spray Technology. Advanced Materials & Processes, vol. 159, no. 9, pp. 49-51, 2001.
- 5 Robinson, M. and N. Jackson, "The Influence of Grain Structure and Intergranular Corrosion Rate on Exfoliation and Stress Corrosion Cracking of High Strength Al-Cu-Mg Alloys," Corrosion Science, vol. 41, no. 5, pp. 1013-1028, 1999.
- 6 Aylor, D.M. and Moran P.J. "Pitting Corrosion Behavior of 6061 Aluminum Alloy Foils in Sea Water," Journal of the Electrochemical Society, vol. 133, no. 5, pp. 949-951, 1986.
- 7 Rech, S. Trentin, A., Vezzù, S., Legoux, J.G., Irissou, E., Guagliano, M., "Influence of Pre-Heated Al 6061 Substrate Temperature on the Residual Stresses of Multipass Al Coatings Deposited by Cold Spray," Journal of Thermal Spray Technology, vol. 20, no. 1-2, pp. 243-251, 2011.

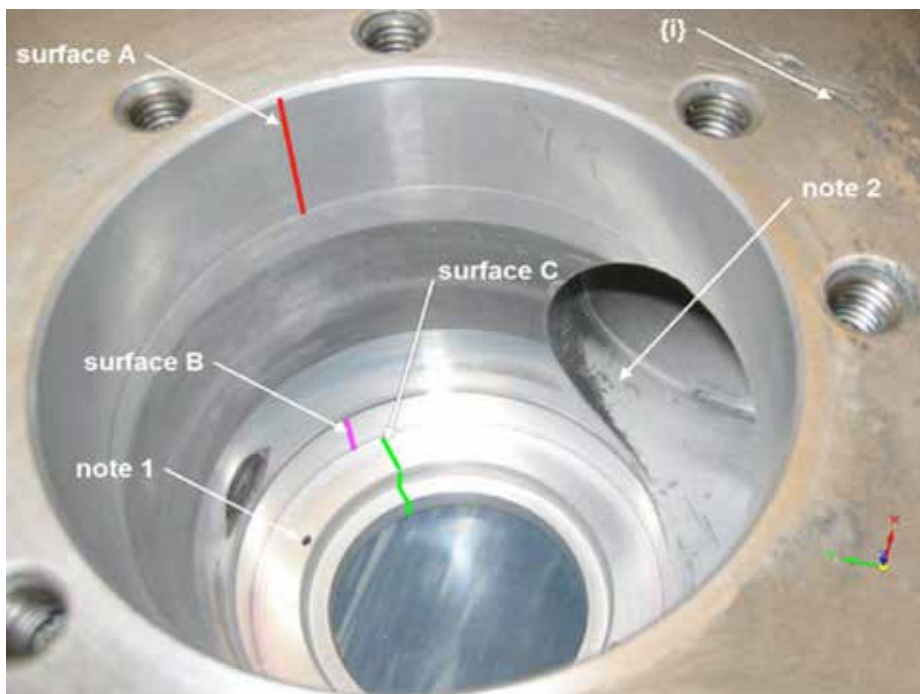


Figure 11. Photo of the final machining performed on the repaired actuator, which was successfully returned to service.

Continued from Page 1

The Admiral has served flag tours as the commander, Naval Air Warfare Center Weapons Division, China Lake/Point Mugu, CA; assistant commander for Test and Evaluation, Naval Air Systems Command; and PEO for Unmanned Aviation and Strike Weapons.

In addition to his Bachelor of Science degree in Mechanical Engineering from Notre Dame,

Admiral Winter holds a Master of Science degree in Computer Science from the Naval Postgraduate School and another in national resource strategy from National Defense University's Industrial College of the Armed Forces; and a Level III certification in Program Management and Test & Evaluation from the Defense System Management College.

The Admiral's personal awards include the Legion of Merit (3), Defense Meritorious

Service Medal (2), Navy Meritorious Service Medal (2), Navy and Marine Corps Commendation Medal (4), Joint Service Achievement Medal (2), Navy and Marine Corps Achievement Medal, Air Force Acquisition Excellence Award, Southwest Asia Service Medal, Kuwait Liberation Medal, and various unit and sea service awards.

INSTITUTE NOTES



iMAST Director, Tim Bair, pauses for exhibit booth photo op with Mr. Thomas Lockhart, Director, Materials and Manufacturing Directorate (AFRL) and Colonel John Gloystein—Deputy Director, Materials and Manufacturing Directorate (AFRL).

Defense Manufacturing Conference 2014

As 2014 came to a conclusion, the annual Defense Manufacturing Conference proved to be another opportunity for members of Penn State Applied Research Laboratory's Materials and Manufacturing Office, under the auspices of iMAST, to attend and participate. The conference, which took place in San Antonio, Texas, was orchestrated by the U.S. Air Force Research Laboratory (AFRL). The theme of this year's conference was: *Defense Manufacturing: Balancing National Security with Fiscal Realities*. ARL/iMAST presentations. Presentations by iMAST principal investigators included: Dr. Tom Juska "Fire Safe Resins"; Dr. Mark Traband "An Approach to Provide Rapid Cost and Manufacturability Feedback to Designers"; Rance Maruszewski "Crack Detection in USMC Combat Vehicles"; Dr. Tim Eden "Cold Spray Procedure for Aluminum"; and Dr. Mark Traband again—with the presentation: "Rapid Build of a Mobility Demonstrator Using a Distributed Enterprise."

iMAST's Novel Composite & Non-Metallic Technologies for Submarine Sail Cost Savings project was nominated for the 2014 Defense Manufacturing Technology Achievement Award. In the end, SCRA's NSAM COE captured the award for their project: F-35 Canopy Thermoforming Automation.

Next year's conference will be held in Phoenix, Arizona. More details will be available in future issues of the iMAST newsletter.



Surface Navy Association Symposium

iMAST recently participated in the annual Surface Navy Association Symposium in Crystal City, Virginia. This year's theme: "Surface Warfare: Distributed Lethality – Going on the Offensive," provide an opportunity for government-contracted defense companies, suppliers and commands to exhibit their latest surface-related warfare technologies in addition to looking ahead at future research and development underway. The symposium provided an opportunity to discuss (and present) a broad range of challenges that can impact the surface community.



Naval Future Force Science & Technology Expo

Members of iMAST participated in the Office of Naval Research biennial Naval Future Force Science and Technology Expo at the Washington D.C. Convention Center. This year's theme, "Innovations for the Future Force", addressed technological advantages for our Sailors and Marines through the Naval S&T Strategy which is: "To discover, develop and deliver decisive naval capabilities, near- to long-term, by investing in a balanced portfolio of breakthrough research, innovative technology and talented people." The next Future Force S&T Expo will be held during 2017. News to follow.



*"Our mission is inherently risky; embrace/manage risk areas, do not avoid them."
—Adm Mathias W. Winter USN (Chief of Naval Research)*

CALENDAR of EVENTS

2015

5-7 May	AHS Forum 71	** Virginia Beach, VA
23-25 Jun	Mega Rust	Newport News, VA
TBA Sep	FMMS	** San Diego, CA
22-24 Sep	Modern Day Marine	** Quantico, VA
TBA Oct	AUSA Expo	Washington, D.C.
TBA Dec	ASNE Combat Systems Symposium	TBA

** Visit iMAST booth