High Pressure Cold Spray Makes Structural Repairs Possible

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What Cold Spray Can Do

Recent advancements in cold spray technology are dramatically expanding what you can do with thermal spray processes. Cold spray can be used to deposit metals on sensitive or difficult-to-weld surfaces for never before possible combinations of unique materials. Cold spray can also be used to repair damaged areas of a finished part, without causing additional problems like warping, cracking, or softening of the part. Furthermore, properties approaching, or in some cases even exceeding the base material properties can now be achieved. This opens the door for cold spray to be used on more than just cosmetic surface restoration, but loaded areas can be repaired including rebuilding entire features on a part (Figure 1).

The technology has been under extensive development for the military as a method to dramatically reduce maintenance costs across the Department of Defense by repairing previously un-repairable assets. An example is a very large aluminum 6061 Navy valve actuator with corrosion damage and internal bore sealing surface wear, which was cold sprayed, re-machined, and returned to service with a savings of over $40,000 per part compared to a new replacement. A collage of the part and the repair process are shown in Figure 2. The as-sprayed 6061 coating had a tensile strength of 38 ksi [262 MPa], 3% ductility, with adhesion strengths well in excess of 10 ksi [69 MPa].

This technology has been extensively developed for high strength aluminum parts, but has also been used to deposit stainless and high strength steels, brass and bronze alloys, nickel alloys, titanium, and even exotic elements like tantalum and niobium. Cold spray doesn’t fix everything, but it has the ability to solve challenges that other technologies simply can’t touch. Finally, once a cold spray process has been developed, it can be applied reliably and repeatedly for a given application.
Figure 2. Cold spray repair of the 3.5 inch internal bore portion and external corroded surfaces of a large Al 6061 valve actuator for an application in the Navy.

How Cold Spray Works

Cold spray, also referred to as supersonic particle deposition, is a high-energy solid-state coating and powder consolidation process. Cold spray uses an electrically heated high-pressure carrier gas, like nitrogen or helium, to accelerate metal powders through a supersonic de Laval nozzle above a critical velocity for particle adhesion. At lower gas pressures, and consequently lower particle velocities, the bonding mechanism is primarily mechanical interlocking with some metallurgical bonding. The strengths are comparable with other traditional thermal spray processes which operate at higher temperatures (Figure 3).

However, at higher pressures, the particle velocities can be increased significantly and can create metal coatings that are anywhere from 2 to 10 times stronger, depending on the material deposited. The step change in performance is the result of a shift from predominantly mechanical interlocking to primarily metallurgical bonding resulting from a high degree of re-crystallization at highly strained particle interfaces. The greater the extent of the re-crystallization across the particle boundaries, the closer the properties of the coating come to meeting book values for wrought materials.
Benefits of Cold Spray

Cold spray is ideal method for efficient application of Metals, Metal Alloys, and Metal blends for numerous applications:

- Cold spray is ideal for parts that are heat sensitive because it can avoid creating a heat-affected zone
- Structural properties can be achieved
- No real limit on deposition thickness
- High deposit efficiency typically > 80%
- Bond strengths > 10 ksi
- Coating Strengths > 40 ksi
- Porosity commonly below 1%
- Powder microstructure and properties are preserved
- No oxide formation, alloy decomposition, combustion product entrapment
- Compressive residual stresses in coating, rather than tensile
Our VRC Product

Our patented and exclusively licensed VRC equipment innovations come from the leading cold spray laboratories and experts in the United States. The advantages to VRC products include:

- **Highest Pressure System on the Market (1000 psi [69 bar])**
  - More applications and better properties with lower cost nitrogen or air
- **Smallest High Pressure Gun**
  - Better nozzle maneuverability means a greater range of applications
- **Modular/Mobile Design**
  - Extended reach and easy adaptability to your custom application
- **Fully Automated Control with Continuous Process Monitoring and Data Recording**
  - Better reliability and repeatability
- **Gas Mixing**
  - Allows for improved properties at lower cost than pure helium

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