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Cold Spray Restoration of Historical Planes

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On the cover: A historical Lancaster World War II plane flies in the Royal Dutch Air Force Open House on June 18, 2005, in Glize-Rijen, The Netherlands. (Photo by Foto VDW/DepositPhotos.)

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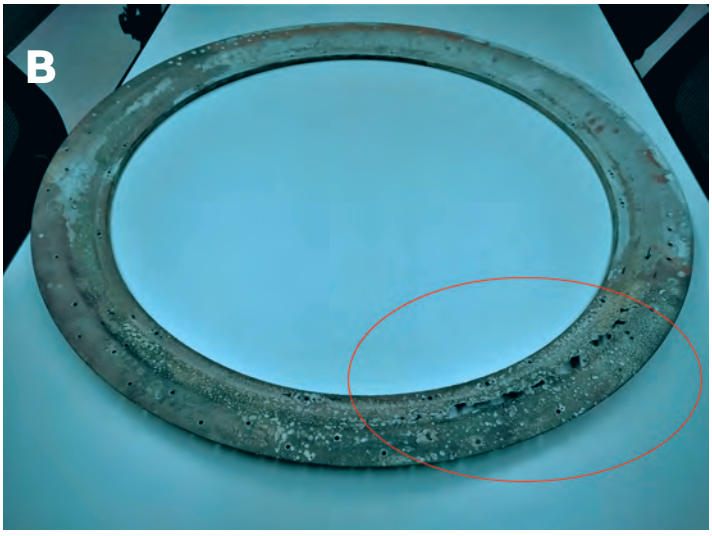
By Julio Villafuerte

Cold Spray Technology Keeps Historic Aircraft Airworthy

A Lancaster bomber flying over Shoreham Airfield in Sussex, England. (Photo by phil_bird/DepositPhotos.)

The Lancaster was a successful British heavy bomber aircraft during World War II. The plane emerged as a redesign of the former Avro Manchester aircraft powered by four 1460 hp Rolls-Royce Merlin engines. The Lancaster first flew in January 1941 and entered production in early 1942. All of the almost 7400 Lancasters produced during the war were committed to nighttime strategic bombing. For these missions, the plane's spacious bomb bays typically carried a mixed load of powerful bombs. Most Lancasters were armed with an assortment of machine gun turrets. After the war, surviving Lancasters served in various noncombat roles, including patrol, photo reconnaissance, aerial mapping, flying tanker for aerial refueling, and even as a long range trans-Atlantic passenger and postal delivery airliner until they retired around 1960. Today, there are about 17 planes remaining in historical static displays, mostly in Canada. At least two of those Lancasters have been restored for airworthiness with plans to continue maintaining them this way.



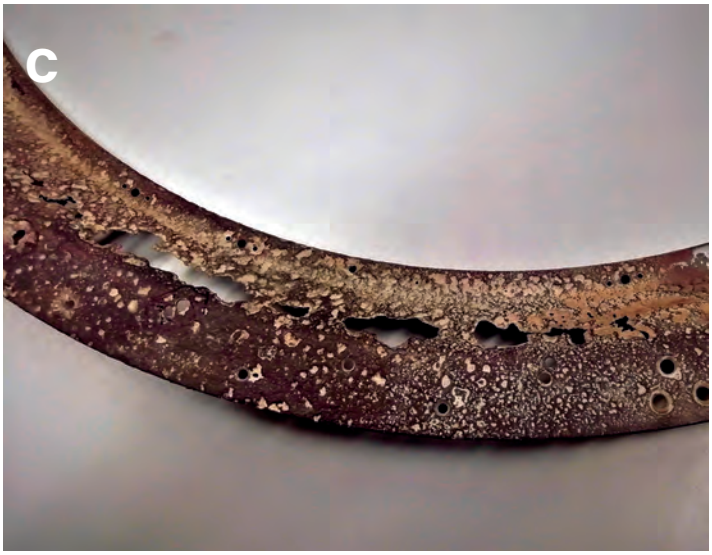


Fig. 1 — A — Rear gun turret (Photo by Paulspixs/DepositPhotos); B, C — part of a heavily corroded turret mounting assembly showing through-thickness corrosion holes. (Photos B and C are courtesy of CenterLine Windsor Ltd.)

Restoration Challenges

Maintaining airworthiness on the Lancaster and other historical airplanes is challenging, at best, due to the lack of spare parts and/or effective repair and restoration processes available. Corrosion typically takes a toll on the aesthetics and functionality of components, many of which are made of treated materials that cannot tolerate elevated process temperatures. One such component is a ring belonging to the mounting assembly of the rear gun turret — Fig. 1. Years of corrosion have created through-thickness holes affecting both aesthetics and the integrity of the assembly. These holes are difficult to restore using conventional thermal processes without affecting the integrity of the part.

Fig. 2 — Commercial SST Series P cold spray manual system. (Photo courtesy of CenterLine Windsor Ltd.)

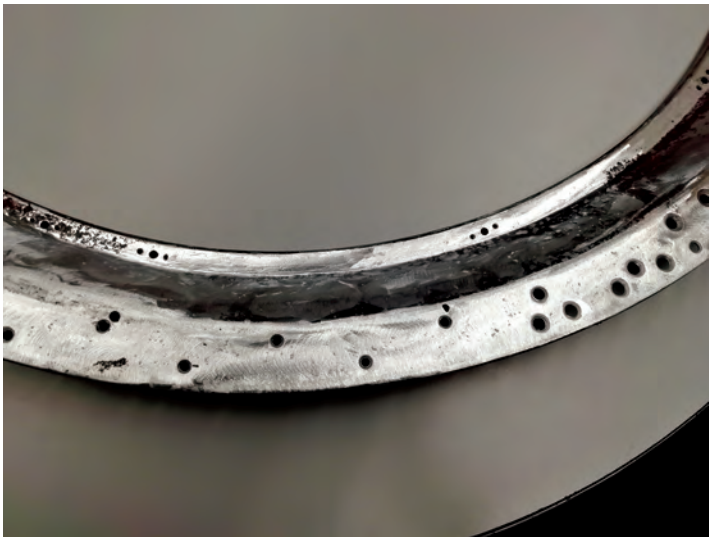


Fig. 3 — The component cold sprayed and grinded. (Photo courtesy of CenterLine Windsor Ltd.)

Since adhesion of the metal powder to the substrate and deposited material is achieved in the solid state, the characteristics of cold spray deposits are quite unique, making cold spray suitable for depositing well-bonded, low-porosity, oxide-free deposits.

Table 1 — Spray Parameters

Machine: SST Series P, manual gun, 2.0-mm orifice, UltiLife™ nozzle

Spray Powder: SST A0050 (aluminum — alumina)

Substrate: Heat-treated steel

Gas: Nitrogen

Surface Preparation: Grit blasting with Grit 80

Gas Temperature: 400°C

Gas Pressure: 180 lb/in.^{2} (13 bar)

Cold Spray Restoration

Cold spray is a solid-state metal consolidation process that uses a high-speed gas jet to propel metal and other powder particles against a substrate where particles plastically deform and consolidate upon impact. The term cold spray refers to the relatively low temperature involved in the process, which is typically much lower than the melting point of the spray material and substrate. In cold spray equipment, air can be used as a propellant gas and temperatures will be low enough not to thermally disturb the substrate material. After low-temperature dimensional restoration of the area, the new consolidated material can be effectively machined back to tolerance using standard machining techniques. Cold spray technology offers the ability of all-metal consolidation for dimensional restoration of manual or robotic applications — Fig. 2.

The Solution

The steel ring was submitted for cold spray repair. First, surface preparation consisted of cleaning and grit blasting. Then, cold sprayed aluminum composite was utilized to manually fill in all repair areas, including through holes, using the spray parameters shown in Table 1. To successfully fill in through-thickness holes with acceptable adhesion, a qualified cold spray operator used a step process consisting of slow buildup around the edges followed by grinding off to prepare the next buildup. The deposits were gradually bridged to close the hole. By repeating these steps, the good adhesion deposits were warranted for final post-spray grinding — Fig. 3.

Conclusion

Since adhesion of the metal powder to the substrate and deposited material is achieved in the solid state, the characteristics of cold spray deposits are quite unique, making cold spray suitable for depositing well-bonded, low-porosity, oxide-free deposits. These attributes make cold spray uniquely suitable for depositing a range of temperature-sensitive materials in this application.

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