

# A Study on Aircraft Propeller and Component Repair with Cold Spray Technology (CST Process)

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**Abstract** – This paper describes Cold Spray Technology and its application on aircraft propellers and their components. This will give the world a clear picture of how the CST process could change the aircraft propeller manufacturing and repair industry. The purpose is to introduce the Cold Spray Technology repair process to aircraft propellers and components such as propeller hubs, spinners, bulkheads, cylinders and propeller blades. Using CST repairs will provide aircraft owners and manufacturers a very cost-effective repair solution. Most of the aircraft propeller and component repair is done with a 7075 aluminum alloy powder coat or a mixture of different aluminum alloys. This makes the repaired component or fabricated area stronger and more corrosion resistant, increasing the life span of the part. However, certain precautions and procedures need to be followed to get successful and cost-effective results. There has been a high success rate using the Cold Spray Technology on military aircraft in many developed countries like Germany, Japan and United States of America and the user has saved more than 60% over the cost of buying new parts. Now is the time to introduce this Cold Spray Technology process to the commercial aviation industry so that every manufacturing and repair company has the opportunity to adopt this technology.

**Keywords** – Aircraft Components repair with Cold Spray Technology; Cold Spray; stress corrosion cracking; Thermal Spray.

## I. INTRODUCTION OF AIRCRAFT PROPELLERS

We are always looking to identify new processes that help the end-user save money on expensive aircraft components. It is very important to understand and adapt cutting-edge technology like the Cold Spray process. The Cold Spray process has already successfully proven its ability to improve industries like Aerospace, Manufacturing, Energy, Oil and Gas, and Transportation.



Fig.1 .Aircraft Propeller (Stocktonpropeller.com).

The aircraft propeller is one of the main components that moves the aircraft through the air by producing thrust.

Most propellers are manufactured with two or more blades, which are held into a hub assembly that is connected to the engine output shaft.

Propeller blades have an airfoil shape just like aircraft wings (Fig1). The propeller is rotated by the power of the aircraft engine and the blades produce lift in the form of thrust to move the aircraft forward. There is a variety of engine and propeller combinations. The propellers are manufactured from Steel, Aluminum, Wood and Composites.

## II. GENERAL PROPELLER PRINCIPLES

There are many types of aircraft propellers manufactured such as;

1. Fixed Pitch
2. Ground Adjustable Propeller
3. Controllable Pitch Propeller
4. Constant Speed Propeller
5. Constant Speed / Feathering Propeller
6. Constant Speed / Reversing Propeller

### 1. Propeller Components and Repair with Cutting-Edge Cold Spray Technology

The main parts of the propeller are Blades, Hub, Pitch change mechanism and Spinner assembly. The propeller is one of the most important components of an aircraft and is critical for performance and flight safety. All propellers need proper attention and maintenance in a timely manner. Propellers are manufactured

with different materials but the important structural components of the propeller hub are built from either an aluminum alloy or steel forgings and blades are manufactured from aluminum alloy forgings or with advanced composite materials.

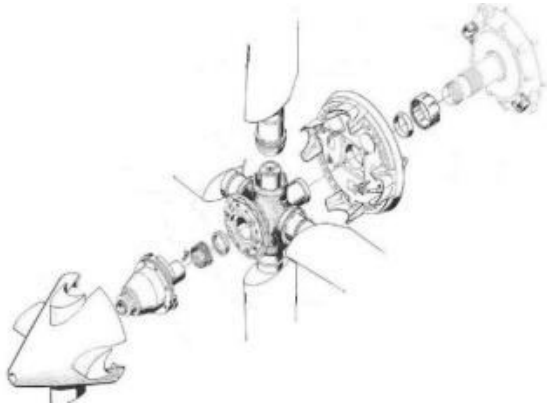


Fig.2. Aircraft Propeller Assembly (aopa.org).

## 2. Propeller Blade Repair with Cold Spray Technology

The most damaged area of the blades is on the airfoil surface area and other than physical damage most of the damage is caused by corrosion. This corrosion occurs not only on the external part of the blades but also internally on the blades on the hub and other parts within the hub. This corrosion damages the structural integrity of the propeller and its performance regardless of where it is located.



Fig.3. Corrosion Areas and Damaged can be repaired with Cold Spray Technology (stocktonpropeller.com).

The above corrosion and physical damage like dings, nicks and small cracks on the propeller blade can be repaired with the help of cutting edge technology like Cold Spray repair technology. Cold Spray repair can be done to any material like aluminum and its alloys along

with steel forgings. This repair makes the part 100% stronger and more corrosion resistant.

Typically, brand new blades cost somewhere around \$5000 - \$8500 each. However; the cold spray repaired blades can save 60%-65% of that cost, so that reduces the price to about \$2000 - \$4000 each.

## 3. Propeller Spinner Assembly Repair with Cold Spray Technology

The aircraft spinner assembly is an aerodynamic cover for the prop. The assembly includes a spinner shell and a bulkhead. Spinner shells are also called domes. Most of them are manufactured from aluminum alloy that is "spun". They are usually painted, or polished. Typically, the spinners and bulkheads are rejected due to worn mounting holes, corrosion or cracks. They can be repaired by welding or by buying a new one. The spinner manufacturers do not recommend welding as they usually crack again right next to the weld.



Fig.4. Propeller Spinner Dome damage can be repaired with Cold Spray Technology (Backcountry Pilot).

These spinner domes cost somewhere around \$2000 - \$6000 for a new one. With the help of cutting edge technology like a cold spray can be sprayed with a hand-held nozzle and deposit a 6061 aluminum powder on the damaged areas. Once cooled, this deposited aluminum can be machined to match its OEM standards. By using this cutting-edge technology, we can save about 55%-60% of the cost, bringing down the cost to \$650 - \$2700 per spinner dome.

Propeller spinner bulkheads are manufactured mostly from the same material as the spinner shell. In technical

terms we call this a die forged aluminum part (spinner-repairs.com). The bulkheads are the main components that support the spinner. These bulkheads cost somewhere \$2000 - \$6000 for new one.



Fig.5. Spinner Bulkheads can be repaired with Cold Spray Technology (stocktonpropeller.com).

By using Cold Spray Technology, we can save about 55%-60% of the cost, bringing down the cost to \$650 - \$2700 per bulkhead, and as we said earlier this technology is very easy and cost-effective.

#### 4. Propeller Hub repair with Cold Spray Technology

Propeller hubs are an important part of the aircraft propeller. Propeller hubs are made from heat treated aluminum alloy forgings, similar to blades. This is the main structure of the prop holding the 2 to 7 blades in place. This is a highly stressed part that can be damaged mostly by corrosion or wear. There are no approved repairs on these parts (Backcountry Pilot). Hubs cost about \$3000 to \$10,000 for a new one. Every aircraft propeller has to undergo a regular inspection and overhaul process and a significant portion of the cost for overhaul is blades and hubs. This Cold Spray technology could be used for the hub wear repair as well as corrosion repair.



Fig.6. Steel Hub and Aluminum hubs-Both can be repaired with Cold Spray Technology (stocktonpropeller.com).

Commercial carriers using turboprop aircraft are looking to implement repairs using additive manufacturing methods (Oak Ridge Lab). Once the area is repaired with Cold Spray technology the performance and life span of the hub is increased and it is stronger than it was previously. This repair technique will also bring the hub back to the original OEM standards. This process helps the client by saving about 60%-65% of the total cost of a brand new hub.

#### 5. Propeller Cylinder repair with Cold Spray Technology

Cylinders are made from either steel or aluminum. The cylinder has a sealing surface for the piston and holds the hydraulic pressure that moves the blades. The piston is attached to the pitch change assembly that rotates the blades to change pitch. The cylinders are typically the only component that can be seen externally when the pitch is changed. They are damaged mostly by corrosion or wear. They can cost between \$1000 and \$5000 for a new one.



Fig.7. Propeller Cylinder Wear and Tear can be repaired with the Cold Spray process (stocktonpropeller.com).

The damaged or worn area can be repaired with the cold spray process. It is very possible for the owners of the aircraft to save about 60% - 65% over the cost of replacing the above components of the propeller by using this cutting-edge technology.

### III. CONCLUSION

Cold Spray powders can be used different metals, compounds, or be a blend of metallic and non-metallic particles. These powders take into account the use of material coatings to fix the surface with comparative or improved materials, or the part includes by splashing onto a surface and afterward machining the ideal highlights into the cold spray (VRCMETALSYSTEMS).

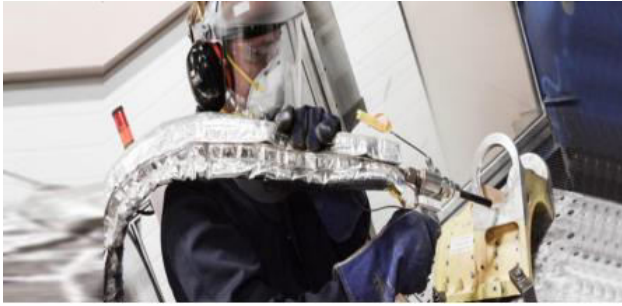


Fig.8. Cold Spray -Spray (vrcmetalsystems.com).

Due to the solid-state deposition of coating, Cold Spray technology is approved and proven as an additive manufacturing process for many manufacturing industries for the fabrication of components and to repair their damaged parts. Cold Spray technology is not only extremely crack resistant but also it is very light in weight and corrosion free on any applied areas. It is also proven that this cutting-edge Cold Spray technology is a cost-effective and fast process technology that can improve the life span of the repaired area.

## REFERENCES

- [1]. Aircraft Maintenance: Know your propeller repair limits. (2017, December 18).
- [2]. Retrieved May 3, 2020, from <https://www.aopa.org/news-and-media/all-news/2017/december/18/propeller-maintenance-part-2-maintenance-and-repairs>
- [3]. Elson, R. Tidball, and A. Hampson, Waste Heat to Power Market Assessment (Berlin: Oak Ridge National Lab. (ORNL), Oak Ridge, TN (United States). Building Technologies Research and Integration Center (BTRIC), 2015).
- [4]. Backcountry Pilot. (2016, September 28). Retrieved May 3, 2020, from <https://www.backcountrypilot.org/>
- [5]. Bulkhead Repair. (n.d.). Retrieved May 4, 2020, from <https://www.spinner-repairs.com/products.html>
- [6]. Technocrackers. (2020, April 16). Propeller Overhaul and Maintenance: Stockton Propeller Inc. Retrieved from <https://stocktonpropeller.com/>
- [7]. Technology. (n.d.). Retrieved May 3, 2020, from <https://www.vrcmetalsystems.com/technology>.