International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 1, Jan-Feb-2021, ISSN (Online): 2395-566X

Propeller Hub Repair With Cold Spray Technology (CST Process)

Dupally Naval Venkata, Narasimha Kishore Yadav
Department of Engineering
Company: Stockton Propeller Inc.
Sacramento, CA-95833
USA

***Abstract*- The current process of the repair by Cold Spray Technology is the restoration of the Aircraft Propeller components and Hub is one of the dynamically stressed components containing aluminum and its alloys and these are the perfect components for the cold spray applications. This application is based on the material of the component that is manufactured and can be repaired with. Most of these cold spray repairing materials are pretreated according to the manufactured material or alloys. Most of the material or metals selected for the cold spray application are compared with the physical, chemical, and mechanical properties of the manufactured components. To optimize the perfect spray bond the closest parameters are subsequently selected, the spay material is applied, and the component is repaired with help of Helium and nitrogen to replace the affected area with spraying powder. Then after the spray, the component is machined in the way it was new and according to OEM standards. This process can be worked on not only Aircraft components, but also any metals used in mechanical, automotive, aerospace, oil and gas, and many other industries where metals need repair and restoration of the damaged area.**

***Keywords*- Aircraft Propeller, cold spray applications, optimize etc. etc.**

I.INTRODUCTION

In current days, the world's leading scientists and aftermarket industry specialists have identified cold spray technology as the money-generating technology. A vast range of this cold spray study is being performed at research centers and been established as a viable coating process to create safety coating, efficiency-enhancing layers, ultra-thick finishing's. Federal governments of different nations have realized the value of this modern technology and various projects are sanctioned to commercialize this innovation. The current study concentrates on maximizing cold spray specifications to create coatings for several materials with preferred microstructures.

Spray coating techniques have been adding more and more due to rapidly advancing cold spray technology. There are many advantages of this cold spray technology and the significant benefit over thermal spray methods are the low-temperature levels included which reduce any kind of potential stage adjustment and keep the bits in their unmodified solid state. The difference between the Cold Spray Process (HVPC) as well as various other thermal spray processes is highlighted in Fig. 1. In the thermal spray process, a covering is created by melting the coating product and afterward relieving the molten droplets.

Thus, thermally sprayed finishes, in general, have microstructures with varying degrees of porosity, oxides as well as various other inclusions, and low deterioration resistance attributes. However, the Cold Spray procedure has the advantage of metal deposition with reduced warm input, neighborhood deposition to limited location, and deposition without oxides, as well as various other inclusions, can be created to any type of metal surface area as well because of compressive stresses, the thick uniform deposit of any kind of density with wrought-like microstructure is obtained. Moreover, the over-splashed costly resources can be collected for reprocessing.

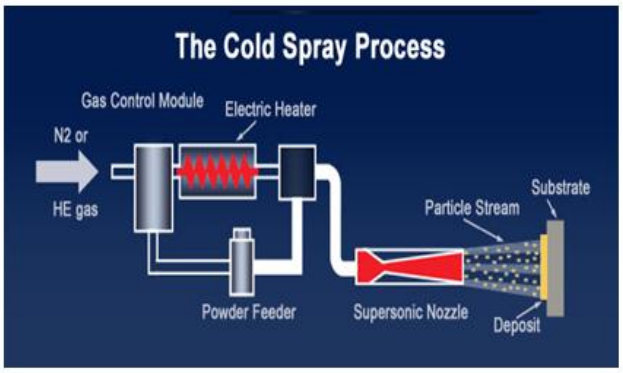

Fig 1. "Cold Spray Technology Process." Aarbgast Material Processing And Joining Laboratory, Www.Sdsmt.Edu.

The increasing technological progress in the aerospace and aviation industry and the resulting growing needs on the product and part framework against the history of constantly increasing cost stress make the economic repair

© 2021 IJSRET

service of the generally extremely expensive components essential today. Nonetheless, the fixing process is made considerably harder by the above-mentioned qualities of aviation components such as Aircraft Landing gear, Fuselage, Fabrication, Aircraft propeller, and their components. For example, negative impacts on the base product need to stay clear. Also, improper handling in the production/ repair service process can create mechanical damages, with extreme heat input in the machining procedure leading to substantial loss of strength.

II. BACKGROUND

Aircraft structures along with landing gears and aircraft propeller and their components are often subjected to used and are good for this coating procedure as they can save lots of money by using this repair technology.

For example, aircraft landing gear and helicopter landing gears are subjected to two types of stress. This component is mechanically equipped and when an aircraft is taking-off or landing they fail for stress and sometimes corrosion and this can impact economically for the industry.

In the US alone turboprops and their components like hub repair service or replacement is approximated to cost air providers approximately around 175-200 million per year.

A substantial portion of that expense is because of the refurbishment of the lightweight aluminum prop hub that is fitted to the steel shaft. Cold Spray technology is the best technology that can repair and executes propeller hub repair on turboprop airplanes for business carriers and is aiming to execute repairs making use of additive production approaches, which extend the life of the metal or components that are cold spray coated.

Fig 2. Minimum Material Condition of the Hub (Stockton Propeller, Inc.)

As is known every component in the aviation industry has some time limit or lapse, so do propeller and its components have to remove at prescribed intervals and must go through reconditioning by an approved FAA repair station to bring the back to the original equipment manufacturer (OEM). They must follow certain machining procedures and inspections like die penetrant that used for detecting the dis continues and other corrosion that occurred. This inspection will help to detect the minimum material condition is occurred. If this condition of the minimum material occurs, then the hub is scrapped as per OEM standards.

Stockton Propeller, Inc. has collaborated with VRC Metals Systems and Midwest America Aviation for cold spray repair on aircraft propellers. The main motive of this collaboration is to evaluate additive industrial methods for the cold spray process to repair the hubs with minimum material condition of the hubs. Firstly, these processes involves the removal of the corrosion to the thickness that is under the OEM standards and spray the coatings to build up the thickness back to OEM standards to the base material of the component or part.

Fig 3. Minimum Material Condition of the Hub (Stockton Propeller, Inc.)

Secondly, the component will be set to perform the failure analysis to find out if the additive cold spray process can be used to restore, alter, and renovate the hubs, this analysis also will find out about the expanding life of the repaired area or equipment. A cost-effective metal repair and modification for the metals have been a big goal for the industries and would have been fulfilled by the cold spray technology invention.

Stockton Propeller, Inc. has been working on an on-going research initiative of alternative cold spray applications and testing procedures to restore the metal components affected by wear and tear and corrosion. With this collaboration, SPI is concentrating its research on aluminum alloy propeller hubs to make sure they sustain the cold spray repairs. Once the SPI finds the successful results, they will write a repair manual and get FAA certification and approval of this process.

SPI is considering different nozzle parameters to create applications on aircraft hubs and propeller components. Below are some of the parameter SPI, have selected and implemented a few of the hub repair applications. These parameters will be used on 6 different hubs with a batch of 2-3 samples and will post the updated results in near future.

© 2021 IJSRET

Table 1. Nozzle Parameters.

Sample No.	Impact Velocity (m/s)	Particle Size (micrometers)	Temperature (K)
1	1250	10	280
2	1000	20	390
3	925	30	405
4	750	40	420
5	625	50	500
6	585	60	550

Table 2. Particle size and Distribution.

Particle Size(micrometers)	Distribution %
15	0.2
20	5
25	20
30	31
35	41
40	49
45	62
50	68
55	72
60	81
65	87
70	92
75	94
80	97
85	99
90	100

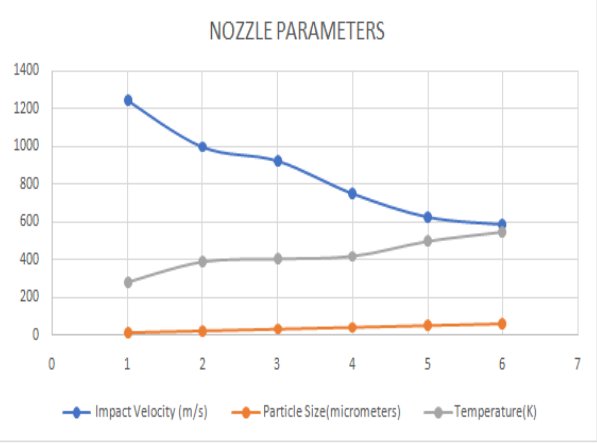

Fig 4. Nozzle Parameters

III. TECHNICAL RESULTS

Most of the hubs that are cracked may not be easy to identify, however; the die penetrant inspection will give the accuracy of the cracks in the hubs. As a result of the typical closeness of the die penetrant indications to the dowel pin holes as well as the damages observed in the very same place on the as-removed hub, options relating to fixing were targeted at the area on the flange face beside the dowel pins. It was always recommended that the new hubs are machined and recessed to protect against contact with fittings if the damage is eliminated more than the thickness of the component.

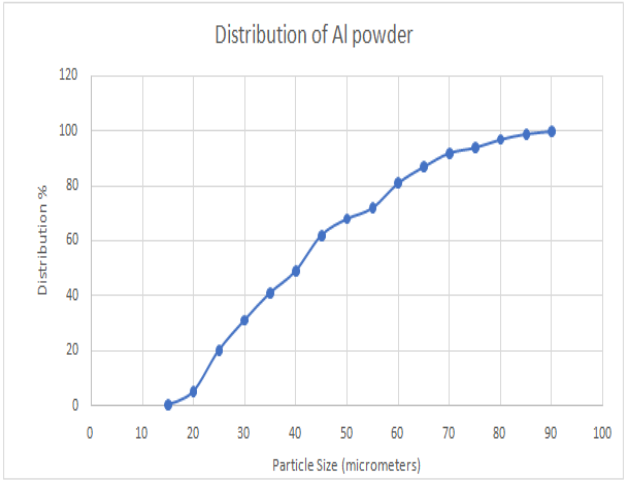

Fig 5. Distribution of Al Powder.

The accurate results for this research will be posted soon once all the specimens are sprayed and tested. To better recognize damage conditions a literary works review will be performed on aircraft propeller hub observations. In some small samples, our team found out that the metal bonding was very brittle and holding perfectly in the repair area. SPI will examine 3 potential benefits that can be published at different phases for thedevelopment of lightweight aluminum alloy propeller hubs.

IV. IMPACTS ON THE INUDUSTRY

Industries have been increasing their fleet and at the same time the fuel cost and maintenance cost are going up day today. Due to this increased cost of fuel, many airlines are considering turbo-propeller engine aircraft are their alternative to their turbojet to operate in the regional market. Any scheduled route less than 1000 miles most of the airlines use the turboprop aircraft, as these turboprop aircraft consume approximately 30% of less fuel than jet aircraft. These turboprop aircraft also cost very little for maintenance, repair, and overhaul inspections.

More than 150 million dollars are spent on the other maintenance and replacing the propeller on turbo-prop

© 2021 IJSRET

aircraft each year. Millions of dollars are invested for most of the wear and tear as well as on corrosion problems on various other aircraft critical parts. With an effective repair work method to the propeller hub/ steel shaft, SPI will hope to increase the life process of the prop assembly certainly not only lowering the plane carriers' direct operating costs however additionally lowering the environmental effect of manufacture and dumping of the replaced parts.

Significantly, SPI thinks that the advancement of repair services for built aluminum parts including the certain instance developed herein would possess numerous possible functions throughout the aerospace market that could possibly lead to potentially billions of bucks of discounts. This successful cold spray application can be the strategical repair to the aircraft propeller and its hubs. SPI is also looking into developing the applications so that they can increase the repaired propeller assembly`s life cycle longer and stronger.

V. CONCLUSION

Cold Spray Technology is not only an evolving innovation but also it should be crystal clear that it is not here to substitute for any of the well-established thermal spray procedures. There have been many researchers that have proven that materials can be sprayed with suitable cold spray coatings. Many industries like biomedical, transportation manufacturers, power plants, and oil and gas are using this technology of Cold Spray applications to benefit the cost-effective and long last life cycle of the components.

Our team at SPI is assessing various applications for the hub repair not only including current and available applications but also working to introduce new applications. To repair the propeller hub my team has acknowledged the relationship between the metals and the powder that will be sprayed on. VRC and SPI together have evaluated a couple of potential solutions that can be implemented in various steps at different phases of aluminum hubs. The cold spray coating procedure has a huge possibility of development with more applications in additional parts in any industry, to improve the life of aircraft parts by staying clear of high temperatures.

REFERENCES

[1] Aircraft Maintenance: Know your propeller repair limits. (2017, December 18). Retrieved May 3, 2020, from https://www.aopa.org/news-and-media/all-news/2017/december/18/propeller-maintenance-part--2-maintenance-and-repairs.
[2] Baker A., Repair of cracked or defective metallic aircraft components with advanced fiber composites-An overview of Australian work, Composite Structures, 30, pp. 153-181, 1984.
[3] Backcountry Pilot. (2016, September 28). Retrieved May 3, 2020, from https://www.backcountrypilot.org/
[4] Bulkhead Repair. (n.d.). Retrieved May 4, 2020, from https://www.spinner-repairs.com/products.html
[5] Hassani, Mostafa &Veysset, David & Champagne Jr, Victor & Nelson, Keith & Schuh, Christopher. (2018). Adiabatic shear instability is not necessary for adhesion in cold spray. Acta Materialia. 158. 10.1016/j.actamat.2018.07.065.
[6] K. M. Sigl, R. A. Hardin, R. I. Stephens and C. Beckermann, "Fatigue of 8630 cast steel in the presence of porosity" International journal of cast metals research 2004 Vol. 17, No. 3.
[7] Muth, Thomas R., & Peter, William H. Aircraft Propeller Hub Repair. The United States. DOI: 10.2172/1237592.
[8] Rokni, Reza & Nutt, Steven & Widener, Christian & Crawford, Grant & Champagne Jr, Victor. (2018). Structure–Properties Relations in High-Pressure Cold-Sprayed Deposits. 10.1007/978-3-319-67183-3_5.
[9] Sakaki K., Cold Spray Process Overview and Application Trends, Materials Science Forum Vols. 449-452 (2004) pp. 1305-1308.
[10] T. Piwowarczyk, M. Winnicki, A. Małachowska, A. Ambroziak, "Casting defects filling by low pressure cold spraying method", Archives of Foundry Engineering, volume 14, special issue 1/2014, 109-114. 2.
[11] Technology. (n.d.). Retrieved May 3, 2020, from https://www.vrcmetalsystems.com/technology .
[12] Villafuerte, J., & Wright, D. (2010-05-01). Practical Cold Spray Success: Repair of Al and Mg Alloy Aircraft Components. International Thermal Spray & Surface Engineering, 5(2), 13-15.
[13] Villafurerte Julio, "Current and future applications of cold spray technology", Metalfinishing (2010).

© 2021 IJSRET