A REVIEW ON SUPERSONIC PARTICLE DEPOSITION AS POTENTIAL SOLUTION FOR AIRCRAFT METAL MOLD REPAIR

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ABSTRACT

The global Maintainence , Repairing and Overhaul (MRO) services industry is forecast to be worth US$65 billion by 2020. Malaysia plans to become a regional hub for aircraft maintenance and repairs. The country was currently ranked fifth in Asia and tenth in the world in terms of aircraft maintenance, repair and overhaul. Maintenance or repair technique play a major role in increasing useful life of the aerospace part and it increase the confident level of the user. Supersonic particle deposition has attracted serious attention because it unique thick dimensional restoration properties can be obtained by the process that is not achievable by thermal spraying. This uniqueness is due to the fact that dimensional restoration deposition takes place without exposing the spray or substrate material to high temperature and its ability to perform a bonding with the underlying material without the creation of heat affected zones which are typical of other deposition processes, thermal spray and are undesirable in many structural applications. This paper is an outcome to discuss supersonic particle deposition process as potential repair technique for aircraft metal mould, which is widely acclaimed for and on top of that, re-use of material will contribute to cost saving and in-haze the environment.

Keywords: *Cold Spray, Supersonic Particle Deposition, Repair, Metal Mould, Aircraft.*

1.0 INTRODUCTION

The supersonic particle deposition or cold spray method is a relatively new process by which coating of ductile materials or composite materials with significant ductile phase content can be produced without significant heating of the sprayed powder. The kinetic energy of the particles is sufficient to produce large deformations and high interfacial pressure and temperature, which appear to produce a solid state bond (Gilmore *et al.*, 2010). Supersonic particle Deposition (SPD) was initially developed in the mid-1980s at the Institute for Theoretical and Applied Mechanics of the Siberian Division of the Russian Academy of Science in Novosibirsk (Grujicic *et al.*, 2004). Experiments were performed in a supersonic wind tunnel with very small particles entrained in the high velocity gas stream. The erosive behavior of this particle-laden flow on an object in the wind tunnel was studied. It was discovered that above a particular minimum particle velocity, the abrasion caused by the particles changes to adhesion of the particles, i.e., a coating is formed on the object. This effect is enhanced by an increase in gas temperature (Stoltenhoff *et al.*, 2002). The global maintenance, repair and services industry in aviation industry involve dimensional restoration or tooling repair for metal mold. Standard practice, manual that provided by OEM of the part will be referred and if the defect, example chipped rotor blade is exceed it repairable limit, the part is considered scrap. In this case, Cold spray process can provide total solution through deposition the thick coating of the same material with the substrate to the chipped area without build internal stress. This will provide cost saving through re-use of the part. Thermal spray technique also involved in dimensional restoration or tooling repair but it lead to build up internal stress in the part, influence fatigue failure of the part. Application of heat in thermal spray also lead to higher porosity compare to cold spray technique and it influence the strength and shorten the life of the part. Objective of this paper is to study cold spray technique as potential solution in dimensional restoration for aviation industry in Malaysia.

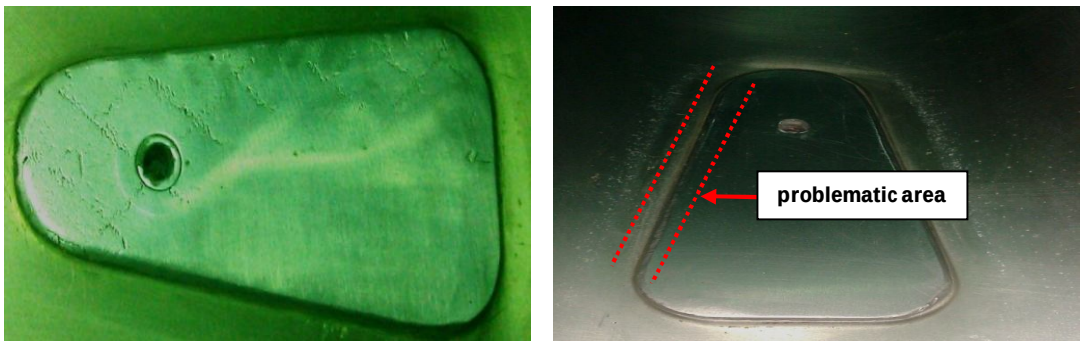
2.0 THEORETICAL OVERVIEW

Cold spray process is a technology in which metal, composite or polymer particles generally 1-50 µm in diameter are accelerated to velocities in a range between 300-1500 m/s by entrainment in a supersonic jet of

compressed gas powder particles to impact a solid surface. The cold spray process utilizes Nitrogen or Helium as a carrier gas with pressures ranging between 100-500 psi. The carrier gas is heated within the gun to temperatures up to about 600°C (Grujicic *et al.,* 2004). Compressed gas of an inlet pressure enters of an inlet pressure and flows through a converging / diverging DeLaval-type nozzle to attain a supersonic velocity. The solid powder particles are metered into the gas flow upstream of the converging section of the nozzle and accelerated by the rapidly expanding gas to achieve higher gas flow velocities in the nozzle, the compressed gas is often pre-heated. These droplets then impact in a substrate to give a high yield of a partially solid deposit of controlled shape. This deposit is cooled by the gas stream and solidification is completed at much slower rates than the initial cooling rates in spray. Particle bonding in cold spray process is due to high rate deformation of the particle, adiabatic shear instability and requires high particle velocity > $V_{critical}$ (Grujicic *et al.,* 2004). Advantages of cold spray technology are low temperature process, which it operate below melting point of metals and this will contribute to porosity control below 1%. High density deposits for dimensional restoration can be done for thick coating at high deposition rate and free form also can be fabricate because of compressive residual stresses contribute from low temperature process without creation of internal stress in the part.

3.0 CASE STUDY

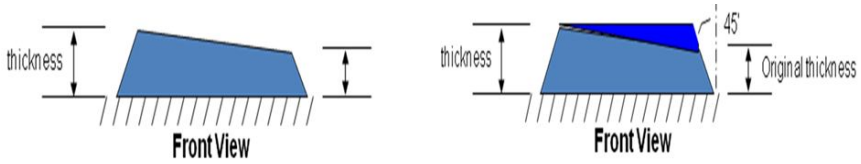
Aircraft fairing is a structure in aircraft design used to reduce drag and improve appearance. Joggle is a part in the nickel shell mold fairing for Airbus A380 as depicted in Figure 1(b). Problem with this joggle are un-even thickness of the joggle and this will lead to un-even fairing structure for A380 as shown in Figure 1(a).This joggle already undergo thermal spray treatment to overcome un-even thickness problem but it not successful.



(a) **(b)**

Figure 1: joggle **(a)** undergoes thermal spray process, uneven thickness and scratches, **(b)** insufficient thicknes.

This joggle is fabricated from Nickel, if using cold spray technique to restore thickness to this joggle area, the same material must be used as shown in Figure 2. Powder feed stock for nickel generally is nickel, Ni, 99.7% basic mixture with aluminum,Al,99.5%, zinc,Zn,99.7% and alumina,Al_20_3,92%. Particle size will be range -45 to 5µm. Carrier gas temperature for nickel powder coating material is 350-500°C, Gun pressure will be 100-200psi with Gun traverse speed 40mm/second and powder feed rate will be 18 gram per minute. Standoff distance will be 10-25mm. Typical coating or restore dimensional properties using all the parameters above will be deposition efficiency up to 32 %, porosity volume less than 0.5 % with Hardness 76-79HRB and bond strength 6500psi.



(a) **(b)**

Figure 2: Joggle **(a)** un-even thickness **(b)** additional thickness required.

4.0 CONCLUSION

Dimensional restoration or tooling repair for aircraft part can be done using cold spray technology. This technology can provide cost saving through re-use of part by dimensional restoration process and in-haze environment by saving energy consumption. It recommended this technology for aviation industry in Malaysia, in-line with Malaysia plans to become a regional hub for aircraft maintenance and repairs and MRO services industry is forecast to be worth US$65 billion by 2020.

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