UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TO STUDY THE MECHANICAL PROPERTIES OF 7075 AL-T6 COLD SPRAYED WITH 6065 ALUMINUM POWDER

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
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Supervisor Name : Dr Noor Irinah Binti Omar

Date : 19.1.2023

DEDICATION

I'd like to dedicate this dissertation to my supervisor, Dr. Noor Irinah Binti Omar, who has been a great help to me throughout this research. My classmates and friends who offered me guidance and encouragement. Finally, I'd want to thank my wonderful parents, who have always been a source of inspiration for me and have always provided moral and spiritual support.

ABSTRACT

Deposits are made by spraying powder particles at high speeds onto a substrate in the cold spray (CS) technique. Cold spray (CS) is the only thermal deposition technique in which particles are deposited below their melting temperature, making it a solid-state processing technique. Coatings created using CS have distinct properties than coatings created using other technologies, which could make CS a viable option for self-standing component repair and possibly fabrication. But, a particle's deformation behaviour is influenced by a variety of material and process parameters which are determined by powder properties, geometric parameters, and processing parameters. Changing any of these parameters causes the deposit's microstructure to evolve and, as a result, the deposit's mechanical characteristics to alter. The purpose of this study is to study the mechanical properties of 7075 al-t6 cold sprayed with 6065 aluminum powder. Important factor such as coating temperature, pressure, coating thickness, particle size which affect the resistane, physcial and mechanical properties of 7075 Al-T6 are stated. Impact testing, tensile strength testing, rockwell hardness testing, surface roughness testing and focus ion beam are used to assess the effectiveness of the CS coating process.

ABSTRAK

Deposit dibuat dengan menyemburkan zarah serbuk pada kelajuan tinggi ke atas substrat dalam teknik semburan sejuk (CS). Semburan sejuk (CS) ialah satu-satunya teknik pemendapan terma di mana zarah dimendapkan di bawah suhu leburnya, menjadikannya teknik pemprosesan keadaan pepejal. Salutan yang dibuat menggunakan CS mempunyai sifat yang berbeza daripada salutan yang dibuat menggunakan teknologi lain, yang boleh menjadikan CS pilihan yang berdaya maju untuk pembaikan komponen berdiri sendiri dan mungkin fabrikasi. Tetapi, tingkah laku ubah bentuk zarah dipengaruhi oleh pelbagai parameter bahan dan proses yang ditentukan oleh sifat serbuk, parameter geometri dan parameter pemprosesan. Menukar mana-mana parameter ini menyebabkan struktur mikro deposit berkembang dan, akibatnya, ciri mekanikal deposit berubah. Tujuan kajian ini adalah untuk mengkaji sifat mekanikal 7075 al-t6 sejuk yang disembur dengan serbuk Aluminium 6065. Faktor penting seperti suhu salutan, tekanan, ketebalan salutan, saiz zarah yang mempengaruhi rintangan, sifat fizikal dan mekanikal 7075 Al-T6 dinyatakan. Ujian keletihan, ujian kekuatan tegangan, ujian kekerasan Rockwell, dan ujian kekasaran permukaan digunakan untuk menilai keberkesanan proses salutan CS.

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LIST OF SYMBOLS AND ABBREVIATIONS

Al	-	Aluminium
ASTM	-	American Society of Testgin and Material
BS	-	British Standard
CGDS	-	Cold Gas Dynamic Spray
CSP	-	Cold Spray
CO_2	-	Carbon Dioxide
CS	-	Cold Spray
Cu	-	Copper
EDM	-	Electircal Discharge Machining
FCG	-	Fatigue Crack Growth
FCI	-	Fatick Crack Initiation
HPCS	-	High Pressured Cold Spray
HRB	-	Hardness Rockwell B
HRC	-	Hardness Rockwell C
IHTC	-	International Heat Transfer Conference
ISO	-	International Organization for Standardization
LPCS	-	Low Pressure Cold Spray
SPD	-	Servere Plastic Formation
TEM	-	Transmission Electron Microscopy
UTS	-	Ultimate Tensile Strength

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CHAPTER 1

INTRODUCTION

The introduction, project scope, problem statement, and project objective will all be covered in this chapter. This chapter will go through the major topic of this research in great depth. The structure of this research's report is also briefly defined to ensure a better visualization of the full research's sequence.

1.1 Background of study

Coating technology has evolved to include a wide range of applications. All coatings treatments used for corrosion protection, aesthetics or appearance, or any other purpose to improve the mechanical and chemical properties' efficacy. Coating materials can be organic or inorganic, and following application, they can form a variety of surfaces. As the mechanical qualities of metal or other composite surfaces, such as corrosion, gradually grow, the technology developed for coating surfaces has become widely used in this generation. Cold spray coating technique was used to solve the majority of the corrosion issues.

Cold spray (CS), also called Cold Gas Dynamic Spray (CGDS), is an additive manufacturing technology which alloys for dense deposition of materials at temperatures below their respective melting points. Micro-sized particles are accelerated to high velocities (usually 300 to 1200 m/s, depending on the substance) conducive to cling to diverse surfaces (Moridi et al. 2014, Schmidt et al. 2006). For many materials that can be created utilizing thermal energy methods, cold spray has the advantage of minimizing residual tensile strains and oxidation concerns. The method can also produce deposits with densities nearing 99

percent in some materials and mechanical characteristics similar to wrought (Champagne and Helfritch 2014).

In the industry, cold spray has been used to coat various metal substrates with thin layers of other metals, as well as to fix dimensional issues in corroded or damaged metal parts (Champagne 2008). Research has been conducted into use of cold spray technology for composites, polymer, and ceramics. This cold spray process has been used to create near net form items since it has substantially higher deposition rates than most other additive manufacturing techniques (Pattison et al. 2007). Cold spray has the drawbacks of poor surface smoothness and dimensional control, as well as the costly expense of helium, which is utilized for greater velocity sprays.

1.2 Problem Statement

Cold spray materials with a long history as aluminum have modified process settings to improve tensile qualities, but fracture, fatigue, corrosion, and wear are only now being investigated (Moridi 2014). Fracture and fatigue properties in cold spray must be understood in the direction of repairs and additively made parts to be employed in structural scenarios. Wear and corrosion qualities must also be thoroughly understood for cold spray coatings to be trusted for long-term service on essential components (Keech et al. 2014). Fitting sponson spar is often the main structural member of the wing, running span wise at right angles to the fuselage of Nuri Helicopter. The spar carries flight loads and the weight of the wings while on the ground. Other structural and forming members such as ribs may be attached to the spars, with stressed skin construction also sharing the loads where it is used (Bruce,2006). Fitting sponson spar Nuri helicopter is made from Aluminium 7075-T6 but premature failure due to corrosion is one of the main challenges associated with this alloy and the most common effect of corrosion on Aluminium alloys is called pitting. It is first

noticeable as a white or gray powder deposit, similar to dust, which blotches the surface (Noor irinah, 2012). Beside corrosion problem, structural restoration that involved mechanical and microstructure properties also another problem to be considered. To date, there has been no detailed investigation of application high pressure cold spray process as dimensional restoration for Malaysian aging aircraft in term of mechanical properties toward adhesion bonding mechanism.

1.3 Research Objective

The aim of this research is to study the mechanical properties of 7075 Al-T6 cold sprayed with 6065 Aluminum powder. The objective of this research is stated as below:

a) To investgate the mechanical properties of cold sprayed Al 6061 on 7075 Al-T6 substrate via tensile testing, Impact testing, hardness testing, roughness testing and focus ion beam.

b) To study the correlation between coating and substrate mechanical properties toward bonding mechanism of cold sprayed 6061 Al on 7075 Al-T6 substrate.

1.4 Scope of Research

The definition of this study is represented in Figure 1. The goal of this study is to investigate into the relationship between cold sprayed 6061 Al coating mechanical properties and adhesive bonding process on a 7075-T6 Al substrate. In addition, this study is also to investigate the qualities of a sample after it has been exposed to cold spray. In this study, an ageing aircraft part (Nuri Helicopter's fitting sponson spar) is used as a sample, which is manufactured of Aluminium 7075-T6. The corrosion effect causes premature failure of the sample. Aside from corrosion, another issue to consider is dimensional restoration, which

involves mechanical and microstructure qualities. As a result, the substrate will be coated utilizing the High Pressure Cold Spay (HPCS) method, which involves depositing Aluminium 6061 powder (Valimet 6061 Al) onto the substrate's surface. This technique involves injecting powder feedstock material (Valimet 6061) with a nominal particle size of 3 microns into the gas stream and accelerating it towards the substrate (Al 7075-T6).

In general, the focus of this research is on the characterization and measurement of the sample after it has gone through the CS process. Tensile Strength Test, Impact Test, Roughness Test, Surface Hardness Test and Focus Ion Beam are the five standard tests used to evaluate this research. All of the tests are part of the material testing process. As a result, the test results are frequently utilized for quality control and to forecast how the material would react under various conditions, such as stresses.

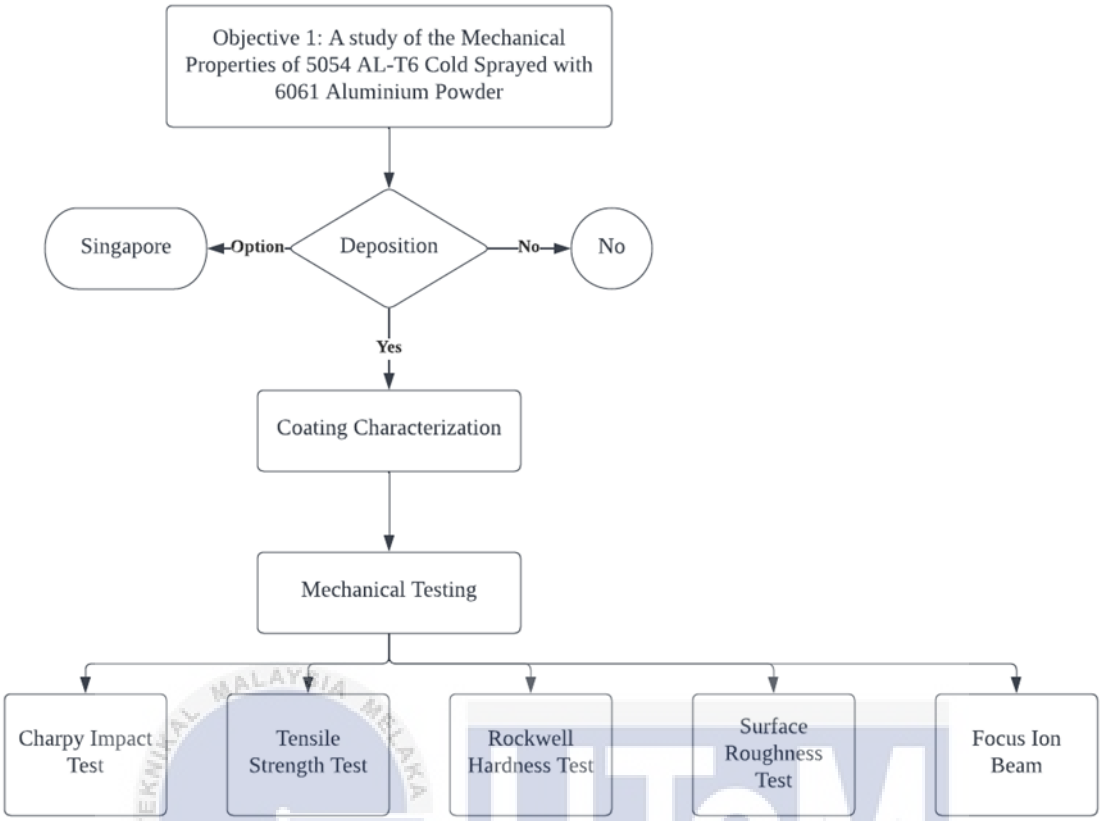

Figure 1.1 Project WorkScope

1.5 Conclusion

This chapter covers the research background, problem statement, objectives, and scope of the research. The following chapter will consist review of main theories and describe previous works related to this research.