



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**STUDY OF COATING PROPERTIES FOR AIRCRAFT
ALUMINUM ALLOY SUBSTRATE**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Manufacturing Engineering Technology (Process and Technology) (Hons.)

by

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FACULTY OF ENGINEERING TECHNOLOGY

2015

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Study of Coating properties for Aircraft Aluminum Alloy Substrate**

SESI PENGAJIAN: **2015/16 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering technology UTeM as a partial fulfillment of the requirements for the degree of Bachelor in Manufacturing Engineering Technology (Process & Technology) (Hons.). The member of the supervisory committee is as follow:

.....

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.....

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ABSTRAK

Kajian ini adalah berkaitan dengan sifat-sifat aloi Aluminium 7075 iaitu bagi projek adalah sebahagian penuaan pesawat udara yang telah disaluti dan dirawat dengan menggunakan teknologi semburan sejuk .Projek ini membincangkan keberkesanan menggunakan teknologi semburan sejuk sebagai rawatan salutan. Objektif utama kajian ini akan mencirikan kepelbagaian ciri saduran Aluminum 6061, Aluminum didepositkan atas Aluminum 7075 bahagian pesawat substrat dengan menggunakan teknik tekanan tinggi semburan sejuk (HPCS). Satu bahagian lama pesawat mempunyai hakisan dan kegagalan pada permukaan serta struktur. Oleh sebab itu, bahagian tersebut telah disadurkan dengan Aluminum 6061 serbuk besi. Melalui kajian ini, serbuk bahan diasak dan memecut keatas substrat yang merupakan Aluminum 7075. Proses saduran tekanan tinggi semburan sejuk (HPCS) telah dinilai dengan pelbagai unsur bagi menjalankan analisis kakisan menggunakan Semburan Garam, ujian mikrostruktur Pelepasan Imbasan Elektron Mikroskop (FESEM), ujian Microhardness dan sinar X Energy Dispersive. Melalui keputusan analisis, teknologi semburan sejuk boleh digunakan untuk merawat bahagian kecacatan bahagian pesawat sebagai rawatan salutan. Keputusan Semburan garam penebusgunaan kurang kakisan berhampiran permukaan dilapisi sampel iaitu Aluminum 7075 disadurkan dengan Aluminum 6061 serbuk. Ia juga terbukti, bahawa teknologi ini boleh digunakan untuk meningkatkan kekerasan bahagian dengan nilai tinggi kekerasan yang mencapai piawaian. Analisis penilaian telah terbukti bahawa teknologi semburan sejuk boleh digunakan untuk meningkatkan struktur kakisan dan kekerasan untuk salutan rawatan.

ABSTRACT

This studies relates to the properties of aluminum alloy whereby is the aging part of aircraft that coated by using the cold spray technology. This project studied the effectiveness of using cold spray technology as a coating treatment. The main objective of this study is to characterize the coating properties of Al 6061 alloy deposited on Al 7075 aircraft aluminum alloy substrate using high pressure cold spray (HPCS) technique. An aging part of aircraft possessed a high value of corrosion and failure, due to the corrosion part is coated with Aluminum 6061 powder. Through this study, powder material was impacted and accelerated onto the substrate using Aluminum 7075. The efficiency of HPCS coating process were evaluated by different of characteristic which involved the corrosion analysis using Salt Spray testing, microstructure analysis using Field Emission Scanning Electron Microscope (FESEM), micro hardness testing and elemental analysis using Energy Dispersive X-ray (EDX).The result indicated that the Cold Spray technology could be used as coated treatment to treat the defect part. Salt Spray also resulted with less corrosion near the surface of coated sample. In addition, this technology was proven on the increase of hardness of the aircraft part. The evaluation analysis has been proven that Cold Spray technology can be used to improve the corrosion structure and hardness for coating treatment.

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DEDICATION

The hardship on executing this project is dedicated to my beloved parents Nisma Binti Kadir and Azis Bin Rejab, my family, my supervisor Miss Noor Irinah Binti Omar, and my best friends for the support and indulgence of easing till the completion of this project.

ACKNOWLEDGEMENTS

First and foremost, I have to thank my research supervisors, Miss Noor Irinah Binti Omar from the Faculty of Engineering technology Universiti Teknikal Malaysia Melaka (UTeM) for her essential supervision. Without her assistance and dedicated involvement in every step throughout the process, this thesis would have never been accomplished. I would like to thank you very much for your support and understanding over these past of one semester. She has been a knowledgeable supervisor to me as a student.

I would also like to show gratitude to my committee, including Ms Fatin Ayuni and Ms Kamal Amirah that give cooperation as a team under same supervisor to complete each part of each other project thesis.

Special thanks to all my peers, my beloved mother, beloved father and siblings for their moral support in completing this degree and not forget to my futsal teammate that have been given a spirit mentally for continue my journey as a student. Lastly, thank you to everyone who had been crucial parts of realization of this project.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
CS	Cold spray
Al	Aluminum
FESEM	Field Emission Scanning Electron Microscope
HPCS	High pressure cold spray
LPCS	Low pressure cold spray
HV	Vickers hardness number
EDX	Energy Dispersive X-ray Analysis
C	Carbon
O	Oxygen
NSS	Neutral salt spray testing
NaCl	Sodium Chloride
HV ₂₀₀	Vickers hardness, weight of load 200g
MPa	Mega Pascal

CHAPTER 1

INTRODUCTION

This chapter will explain about the introduction, project scope, problem statement and the objective related to this project. The main topic of this researched will be discussed in detailed through this chapter.

1.1 Project Background

Application of coating nowadays has reached many type of technology. All coatings treatment used for corrosion protection, to provide good aesthetics or a good appearance, or any other purpose for increase the effectiveness of mechanical and chemical properties. The material that used for coating may be organic or inorganic and after the application it may form other form of surface. The technology that created for coating surface have been widely used in this generation as the metal or other composite surface gradually increase of their mechanical properties problem for example corrosion. Most of the corrosion problem was solved by using cold spray as a coating technology. Cold spray technology is a process by which particulates are deposited by means of ballistic impingement upon a suitable substrate at supersonic velocities to form a coating structure (Smith, 1998). Cold spraying is instinctively new coating process by which coating can be done without significant heating of the sprayed powder. The concept of cold spray is by accelerated metal powder in high velocity on the substrate. The carrier gas will be compressed and heat up for inject with the powder in powder feeder and accelerated to the substrate by high speed of velocity (Gilmore, 2004). Thus, for this project aluminium (Al 7075) is chosen as a substrate for coating and aluminium 6061 as

powder material coated the substrate, the overall structure in this project is to study the coating properties aging part of aircraft. Aluminium alloy are being increasingly used in the aerospace, automotive, and electronics industry (Stoltenhoff, 2001). However, due to surface rustiness, aluminium alloy component are offer to conduct by a surface treatment coating.

1.2 Problem Statement

Aluminium alloy is widely used in the aircraft industries. Aluminium and its alloys have excellent physical and mechanical properties for a number of applications. However, through the studies of analysis aluminium characteristic, the possibility of corrosion for aluminium alloy was very high. This is cause from the high chemical activity in the microstructure due to anodic linking to all other structural metals. From that, it will corrode differently when coupled with virtually any other metal in the presence of an electrolyte or corrosive medium. In addition, aluminium alloys also very susceptible to surface damage due to impact linking, which occurs frequently during manufacture and repair. From that, the scratches and tool marks or contact from improper conduct or handling will cause preferential corrosion locations and different type of corrosion eventually penetrate down to the base metal. One of the example corrosion that occur on the metal is pitting corrosion. Pitting corrosion is a form of particularly localized corrosion that can cause to the creation of small holes in the metal. Due to some holes defect found around the metal it will cause to another effect of the metal. In order to reduce the aluminium (Al 7075) corrosion and defect, the application of cold spray deposition was applied toward the aging aircraft part to investigate the coating properties of cold spray.

1.3 Objective of Study

The objective of this project is to characterize the coating properties of Al 6061 powder deposited on Al 7075 aircraft aluminium alloy substrate using cold spray process.

1.4 Project Scope

The scope of this project mainly purposes to eliminate the corrosion problem on the aging part aircraft aluminium alloy substrate. In order to achieve the objective of this project, the countermeasure of this problem will be conducted by study the coating properties of the Aging aircraft part (Fitting sponson spar of Nuri helicopter) as the main sample. The focus of this project is basically using cold spray technology as a main mechanism to eliminate and treat the corrosion on the aging aircraft part substrate. The scopes are listed out as follows:

1.4.1 Substrate

The sample substrate for this project is Aging aircraft part that made by Aluminium 7075-T6 series. The main coating technology used in this project is High Pressure Cold Spray (HPCS) technique. Aluminium alloy (Al 7075) is treated and laminated from the corrosion problem. The primary concern for this project was to develop specific surface treatments to reduce corrosion, increase surface hardness, and overcome impact damage of aircraft aluminium alloys in order to extend equipment service life.

1.4.2 Powders

As for the powder material for cold spray deposition, the material that applied is Aluminium 6061 powder particle. Aluminium 6061 particle had better pitting corrosion resistance due to material mechanical properties. Al 6061 coating powder was impacted on the aluminium alloy (Al7075) substrate. Aluminium being lower density and high ductility of material is a good candidate for cold spray process. Aluminium powder is one of the materials that can sustainability on variance of substrate.

1.4.3 Testing

Cold spray is the newest of the thermal spray process that mainly used for coating treatment. After the aluminium alloy (Al 7075) coated by Al6061 powder, it will go through a testing for evaluation their effectiveness after the cold spray treatment. The standard tests that will be conduct is salt spray for corrosion test, field emission scanning electron for microstructure image, microvickershardness test for hardness test and Energy Dispersive X-ray Analysis for element composition test. The result of this test will be review by experimentally and theoretically data.

CHAPTER 2

LITERATURE REVIEW

This chapter will explain about the framework of this project. The coating properties of Al 7075 by using cold spray mechanism will be explained detailed by comparing all of the research about this project. This chapter will obtain overall concept of the research that influenced by the theory of the project.

2.0 Introduction

The cold spray process developing a new and portable technique for depositing coating of sample in the solid state without implicate any heat process. As for this project Al 6061 powder was used as coating powder and Al 7075 as substrate for cold spray process. Aluminium alloy commonly used for construction of aircraft and automotive industry, however due to high chemically activities, the part are prone to pitting corrosion. As the main mechanism for coating, cold spray produced the residual stress that will plays an important role in coated the substrate using metal powder. The form for remaining stress in cold spray was influence by varies type of factors such as rapid cooling of the sprayed material, plastic deformation of bonding due to impacted particles, and mismatch of coating from powder and substrate (Ghelichi, 2012). For this research, High Pressure Cold Spray (HPCS) was implemented, High Pressure Cold Spray (HPCS) process flow is developing by thermal spray coating technology that can produce in conventional way system (Athens,2004), nanocrystalline, and amorphous coatings as stated by Christoglou and Athens (2004). In this process, the powder particles are not in a softened, semi molten, or molten state but it is believed that they remain in their solid state

throughout the deposition process. A fine powders particle that is Al 6061 powder are injected in a supersonic gas flow and accelerated above a critical velocity. Then from the impact on the surface Al 7075 substrate, the particles deform plastically and bond to the substrate to form a coating layer. Deformation or increased residual stress pressed by the current coefficient of expansion mismatch that develop as the coating and substrate cool down after the deposition form are regular in thermal spray processes (Hong et al., 2010). Based on the statement stated by Hong and Gang (2010) even if the coating remains attached to the substrate, high residual tensile stresses may bring an unacceptable distortion that significantly reduce the bond strength between the structures. Cold Spray process is a technology that capable to depositing a wide variety of aluminium alloy and composite coatings. Nowadays, aluminium alloy components on commercial aircraft are protected from corrosion by three layer coating system consist of conversion coating, primer coating, and a top coat (Liao et al., 2011).

This basic coating however does not susceptible enough to prevent corrosion defect on the surface. By using the cold spray, it can treat and rebuild the defect material; the component could be treated and used as many times as necessary until the suitable structure has been reached. The cold spray coating provides impact onto the metallic substrate and it will create new interfaces metallic bonding (Bolot, 2011). Bolot (2011) indicated that the new structure layer of the material will create a new arrangement of deformation in the structure. The main objective of this project was to determine the coating properties condition of Al 7075 substrates. Few studies have been going through at the characteristic of Al 7075 alloy coatings produced by the HPCS. For this purpose we performed several mechanical and electrochemical testing to evaluate the quality of coatings achieved under a range of spraying condition.

2.1 Cold Spray Process

A cold spray system with a commercial spray gun was employed to deposit coatings (Chang, 2010).The cold spray (CS) was invented in the mid – 1980s at the

Institute of Theoretical and Applied Mechanics, the Russian Academy of Sciences Novosibirsk (Juha et al., 2007). Since then, the cold spray process has been referred to as cold-gas dynamic-spray (CGDS) (Planche, 2011) and kinetic spray (KS). Anatoli Papyrin, the inventor of the cold spray process, along with other researchers have shown that the cold spray technology can be used to apply a wide variety of metallic, dielectric (ceramics), metallic alloys, and mixed combinations on variety of substrate material (Dykhuizen, 2004). Cold spray offers a several advantages beside to other coating systems and deposition processes. Being low-temperature method, cold spray operates beneath the melting point metals of the particulate material, require no fuel or gases and create very low porosity deposit (Gilmore, 2004). The principle of Cold spray process is by injected into the gas stream in the nozzle, and propelled toward the substrate to be coated (Villafuerte et al., 2011). The compressed air were used as the main gas and powder carrier gas that controlled in high pressure or low pressure state.

The temperature of gas stream is always below the melting point of the Al 6061 powder during the cold spray, and the result of bonding material is formed in the solid state. In perspective of the fact, bonding deformation powder to substrate, and also the consistency of deposited material that perfect in the solid state with low temperature can influence the features of the denseness deformation and also quite characteristic in many regards. Based on the Figure 2.1, the deformation of powder particles and substrate can be divided into four type of bonding deformation that is soft particle with soft substrate, soft particle with hard substrate, hard particle with hard particle and hard particle with soft particle. A cold spray process is still in its improvement stage, in this study the points is to assessed the properties of Al 7075 coating properties of the aircraft part using cold spray as the coating technology. Cold spray technology can be applied to a wider varies of substrates and residual stresses are basically compressive in nature, due to the physics of the impinging. The longer qualities of cold sprayed material are required by certain applications, for example the high electrical conductivity of cold spray material favour their use in electronic application (Gilmore, 2004). From the description from Gilmore and Dykhuizen (2004) has been stated that cold spray basically can be applied for varies type of material in order to maintain their phase of structure.

From the explanation of previous research, the presents work that is in this research attempts to describe and study the coating properties for Aircraft Aluminium Alloy Substrate by using Al 6061 powder. The effect were measured and evaluated through the microstructure test, corrosion test, and hardness test.

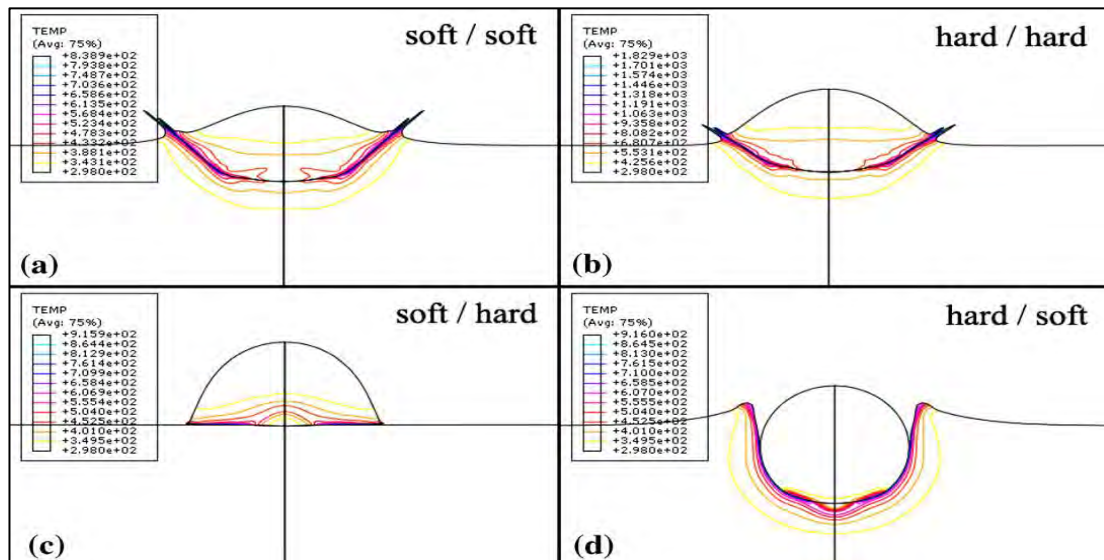


Figure 2.1: Classified of particle impact on substrate at the velocity of 650 m/s.

(a) Soft particle to the soft substrate (b) hard particle to the hard particle (c) soft particle impact to hard substrate lastly (d) hard particle to the soft substrate

(Villafuerte, 2011)

Figure 2.2 shows a diagram for overall gas temperatures and average of particles velocities in different thermal spray processes. From the decade of time, improvement of thermal spray technique has been gradually increase follows the year. The improvement of thermal spray process from decade has been affected the technology by giving a chance for release the cold spray process as a pure and dense coating formation with low and less level oxidation during. Cold spraying was developed in the former Soviet in 1980's. The cold spray process also provided a low heat input and not change in the substrate properties, and avoiding the oxidation during spraying (Zheng et al., 2011). From the previous research, Villafuerte and Zheng (2011) found out that cold spray process do not involved any high temperature, due to that there are no change in the phase for sample properties even in different type of sample.