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PERFORMANCE ANALYSIS OF THERMAL ARC SPRAY ALUMINIUM COATING AS A SACRIFICIAL ANODE

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Thermal arc spray coating is a protective coating which useful to protect steel surface from environment condition. Thermal arc spray coating offers better protection due to its capability to withstand high temperature and better corrosion control with low operation cost. Thermal arc spray coating is applied extensively in atmospheric condition to reduce corrosion rate but very less used in seawater condition. Most duty as a corrosion protection for subsea structure is carried out by cathodic protection system; putting anode as a sacrificial to protect cathode from corrosion. This research investigates suitability of aluminium material to be as a sacrificial anode and evaluate thermal arc spray aluminium coating performance as a sacrificial anode for structure protection under seawater condition by applying different coating thickness. Efficiency of aluminium alloy 99.5% material as sacrificial anode was studied by using DNV RP B401 Standard and measured by important parameters such as potential difference, anode efficiency, consumption rate and corrosion rate. It found that the material produced good consumption rate between 2.9 kg/A.year to 3.42 kg/A.year, high anode efficiency recorded at 96%, and constant potential difference at -0.712 V. Since aluminium alloy 99.5% give a good performance, then the material was used as a coating material in thermal arc spray application. 15 samples were prepared where all samples sprayed with different coating thickness ranges from 200 μm to 700 μm and immersed in artificial seawater. Daily data were recorded such as potential difference, salinity concentration, pH and corrosion rate in 12 months experiment. After completed the experiment, laboratory tests were conducted. The surface structure and cross section were examined by scanning electron microscope and energy dispersive x-ray. The hardness was inspected using Vickers Hardness testing. Surface roughness was inspected using InfiniteFocus G4 machine. From experimental results, it shows that the coating produced low corrosion rate at range of 0.013 mm/year to 0.025 mm/year and recorded potential difference between -0.79 V until -0.886 V. It indicated that the sacrificial work well in coating form. It was supported by energy dispersive x-ray result which found calcium carbonate compound exists on the coating; increasing in coating thickness directly reduced the coating hardness from 51.2 HV to 46.6 HV. The highest hardness was at coating thickness of 200 μm to 300 μm. It was observed only small change or no direct correlation between surface roughness and coating thickness. Overall, it can be concluded that the coating thickness at 500 μm-600 μm provides better coating performance in terms of optimum potential difference and lesser corrosion rate.

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

Corrosion is one of the critical problems exist in industry and many companies struggle to overcome the problem. It holds as a main stumbling block especially in oil and gas industry or aircraft industry. From the moment part of metal is manufactured, it must be protected from its environment to avoid or minimize corrosion. Mild steel is a common metal widely used in engineering application such as in manufacturing industries, construction, marine and automotive. Even though mild steel shows favorable mechanical properties and more cheaper, its performance in long services in aggressive environment especially in marine condition not really good due to low corrosion resistance**[1]**. Term of 'corrosion' can be defined as deterioration of a substance properties due to chemical reaction with environment **[2-4]**. It means this deterioration give impact either changing in smooth surface, weaken the structure, and worst case giving damage to structure.

Corrosion can be considered as a hazard since it will cause fatal accident and expensive damage in every aspect. Due to this reason, corrosion especially in the oil and gas industry has been viewed and given high impact on capital and operational expenditures (CAPEX and OPEX) and health, safety and the environment (HSE) . Base on U.S corrosion study between 1999 to 2001, direct corrosion cost is $276 billion per annum and this figure is 3.1% of their Gross Domestic Product (GDP)**[5].** This is a huge cost and some of money can be saved for country development if corrosion is controlled. If corrosion is poorly controlled, it can give bad impact to plant and equipment serviceability. It will lead to high risk when pipe leaking especially in discharge of flammable gas/liquid such as crude oil or methane gas **[6].** So it will increase environment contamination and raise potentially serious health and hazard.

To handle corrosion problem, a lot of methods were introduced such as using sacrificial anode for cathodic protection, impressed current cathodic protection and