EFFECT OF PULSE ON THE SURFACE PROPERTIES OF MILD STEEL USING TIG TORCH PROCESS

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DECLARATION

I declare that this Choose an item. entitled “Effects Of Pulse On The Surface Properties Of Mild Steel Using TIG Torch Process ” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 11/1/2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical And Manufacturing Engineering Technology with Honours.

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DEDICATION

This research project is decided to all my family members and friends. To my beloved parents, Ahmad Zubir Bin Hanafi and Zarina Binti Kassim, thank you for all the affection, trust and moral support whenever any challenges get tougher. Their unconditional love makes me trying the best for this research project. All my fellow friends are deserved to be partnership in my success of the project. They have provided me a lot of miscellaneous aids when things go wrong. To my honor supervisor, Ir. Ts. Dr. Lailatul Harina Binti Paijan, thank you for willing to teach and assist me with with the problems I faced throughout my project.

ABSTRACT

Mild steel is a type of steel that is low in carbon content and has a relatively low tensile strength. It is also known as low-carbon steel or plain-carbon steel. This steel is widely used in various industries such as production of buildings, bridges, and other infrastructure. It is also used in the manufacturing of machinery and equipment, as well as in the automotive and aerospace industries. However, this material experienced wear and hardness failure during service. Therefore, a new development of surface modification has been introduced in this work by depositing the alumina powder into mild steel via TIG torch melting techniques. The process parameter for this works consists of pulse in the range from 1 to 10 pulse per second (PPS) and current from 80 A to 100 A. The hard surface layer produced from the surface modification was characterized using optical microscope, scanning electron microscopy (SEM), hardness tester, X-ray diffraction (XRD) and surface roughness tester. Based on the experimental results, it was found that the hard surface layer produced maximum hardness of 95.63 HRB with melt layer of 4.1 mm in sample processed under pulse of 1 PPS. The development of martensite structure contributes to the increment of hardness properties. It was found that the intermetallic compound of FeAl and FeO_3 were detected from XRD result which indicating the existence of alumina particles in the hard surface layer. In overall, it can be demonstrated that this surface modification is capable to produce hard surface layer on mild steel with higher hardness and better surface roughness properties which can be used for wear application in various industries.

ABSTRAK

Keluli lembut ialah sejenis keluli yang rendah kandungan karbon dan mempunyai kekuatan tegangan yang agak rendah. Ia juga dikenali sebagai keluli karbon rendah atau keluli karbon biasa. Keluli ini digunakan secara meluas dalam pelbagai industri seperti pengeluaran bangunan, jambatan, dan infrastruktur lain. Ia juga digunakan dalam pembuatan mesin dan peralatan, serta dalam industri automotif dan aeroangkasa. Walau bagaimanapun, bahan ini mengalami kegagalan haus dan kekerasan semasa perkhidmatan. Oleh itu, satu perkembangan baru pengubahsuaian permukaan telah diperkenalkan dalam kerja ini dengan mendepositkan serbuk alumina ke dalam keluli lembut melalui teknik peleburan obor TIG. Parameter proses untuk kerja-kerja ini terdiri daripada nadi dalam julat 1 hingga 10 nadi sesaat (PPS) dan arus dari 80 A hingga 100 A. Lapisan permukaan keras yang dihasilkan daripada pengubahsuaian permukaan telah dicirikan menggunakan mikroskop optik, mikroskop elektron pengimbasan (SEM), penguji kekerasan, pembelauan sinar-X (XRD) dan penguji kekasaran permukaan. Berdasarkan keputusan eksperimen, didapati lapisan permukaan keras menghasilkan kekerasan maksimum 95.63 HRB dengan lapisan leburan 4.1 mm dalam sampel yang diproses di bawah nadi 1 PPS. Perkembangan struktur martensit menyumbang kepada peningkatan sifat kekerasan. Didapati sebatian antara logam FeAl dan FeO_3 dikesan daripada keputusan XRD yang menunjukkan kewujudan zarah alumina dalam lapisan permukaan keras. Secara keseluruhannya, boleh ditunjukkan bahawa pengubahsuaian permukaan ini mampu menghasilkan lapisan permukaan keras pada keluli lembut dengan kekerasan yang lebih tinggi dan sifat kekasaran permukaan yang lebih baik yang boleh digunakan untuk aplikasi haus dalam pelbagai industri.

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Completing any sort of project successfully necessitates the assistance of a lot of individuals. I also got assistance in the development of this study from a variety of sources. There is now a little effort to express my heartfelt thanks to that wonderful individual.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
PVD	-	Physical Vapor Deposition
CVD	-	Chemical Vapor Deposition
TIG	-	Tungsten Inert Gas
SEM	-	Scanning Electron Microsopy
XRD	-	X-ray Diffraction
Al_2O_3	-	Alumina Powder
ASTM	-	American Society for Testing and Materials
MPa	-	Megapascal
GPa	-	Gigapascal
GTAW	-	Gas Tungsten Arc Welding
GMAW	-	Gas Metal Arc Welding
SMAW	-	Shielded Metal Arc Welding
Al	-	Aluminum
Zn	-	Zinc
MAB	-	Manganese-Aluminium- Bronz
MIG	-	Metal Inert Gas
PAW	-	Plasma Arc Welding
WC	-	Tungsten Carbide
Ti	-	Titanium
Si	-	Silicon
C	-	Carbide
°C	-	Degree Celsius

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CHAPTER 1

INTRODUCTION

1.1 Background study

Accordingly, the present study attempts Balaram Naik & Chennakeshava Reddy, (2018) the most advanced production technology includes metal connectors, metal welding, material quality, and durability. Welding is the technique of connecting two metals using a combination of metal bases and filler material added to the surface of molten metal to create a strong bond between the metals. In tungsten arc welding, a tungsten electrode with a continuous welding power source is utilised to create an electric arc between the electrode and the workpiece, generating heat to form the weld.

Other studies by Jiang, P. et al. (2016) an arc welding process, Gas Tungsten Arc Welding (GTAW), also known as Tungsten Inert Gas Welding (TIG), uses non-weldable tungsten electrodes. The welding area and the electrode are both shielded from oxidation and any other impurities present in the environment by an inert shielding gas (argon or helium). Filler metals are utilized quite commonly, but there are types of welds known as autogenous welds or composite welding that do not require filler metals. The GTAW welding technique is often used to join relatively small pieces of stainless steel and non-ferrous metals, such as aluminium, magnesium, and copper alloys. This method gives the operator a more significant degree of control over the welding process than competing methods, such as shielded metal arc welding and gas metal arc welding. As a result, it is possible to produce welds of a more considerable quantity and a higher quality. The Gas Tungsten Arc Welding technique, generally known as GTAW, is significantly slower than the majority of other welding processes and more complicated (Jiang, P. et al. 2016).

In different study Yelamasetti & Rajyalakshmi, (2019) say that in the mode known as pulsed current, the welding current jumps back and forth between the two settings very quickly. The current condition at the upper level is referred to as the pulse current, while the current level at the lower level is referred to as the background current. The weld area is heated up, and fusion takes place during the interval that the pulse current is being applied. The weld region is allowed to cool down and become more solid when it falls into the background current. Pulsed current GTAW has many benefits, including a decreased heat input and, as a direct result, a reduction in distortion and buckling in thin workpieces. In addition to this, it grants a better degree of control over the welding pool and has the potential to enhance weld penetration, welding speed, and welding quality.

1.2 Problem Statement

Mild steels are widely used in various industrial sectors due to their excellent strength, low-cost materials and ease of fabrication. However, this material suffers from hardness and wear resistance properties. Therefore, surface modification is required on this material by using a mixture of alumina powder as a coating on the mild steel surface because alumina powder has high hardness, excellent corrosion resistance and high melting point. A common problem encountered on the surface during welding is the lack of fusion at the root. Therefore, by using the pulsed method to find the effect that can melt the rod on the surface is able to harden the layer on the surface.

1.3 Research Objective

a) To develop a new hard surface layer on mild steel using alumina powder preplacement and TIG torch process.

b) To evaluate the effect of pulsed-TIG welding on mild steel in terms of hardness, microstructural, and surface roughness.

1.4 Scope of Research

- The process parameters used in this project is pulse from 1 – 10 PPS, current (80 – 100 A) and constant gas flow rate 15 L/min.
- The development of hard surface layer is examined and characterized using Optical microstructure (OM), Scanning Electron Microscopy (SEM), Rockwell hardness test, X-ray diffraction and surface roughness.

CHAPTER 2

LITERATURE REVIEW

2.1 Steel

Researchers have studied about steel Islam & Rashed, (2019) say steel is a generally acknowledged, iron-rich ore-derived, versatile, complex metal substance. The infinite diversity of microstructures for allotropy, availability, abundance, and characteristics achieved by solid-state transformation and straightforward processing procedures have given steel a competitive advantage over other materials. Iron ore is abundant in the earth's crust and is easily reduced by heated carbon to produce iron, with a melting point of approximately 15431°C. Ordinary carbon steel comprises 80% of all metallic materials and is the most extensively used iron in the industrialised world. It can also be cast and heated to provide a range of mechanical qualities, beginning with modest yield strengths (200–300 MPa or 30–40 KSI). Ductility to yield strengths over 1400 MPa (200 KSI) with fracture toughness levels as high as 110 MPa (100 KSI), allowing it to be utilised in a vast array of applications.

2.2 Types of steel

There are four main types of steel, carbon steel, alloy steel, stainless steel, and tool steel. Each type of steel has unique characteristics that lead it to be used in its respected fields. In this project, the steel used is a mild steel.

2.2.1 Carbon steel

Previous studies have primarily concentrated on carbon steel Singh, (2020) say carbon steel, an iron-carbon alloy, is the least expensive metal for pipes and valves. This substance is classed as a non-corrosive alloy that is susceptible to carbon dioxide and hydrogen sulphide corrosion. Carbon steel can be alloyed with silicon, copper, and manganese. Carbon steels can be classified as low carbon with a carbon content below 0.25%, medium carbon with a carbon content between 0.25% and 0.5%, and high carbon with a carbon content between 0.5% and 1.25 %. If the iron-carbon alloy has more than 2% carbon, the substance is called cast iron. Before the invention of plastic pipes, cast the iron was frequently used for sewage and water pipes. Table 2.1 show the properties inside carbon steel.

Table 2.1 properties of carbon steel by (Singh, 2020)

Property	**Carbon Steel**
Density (1000 kg/m^3)	7.85
Elastic Modulus (GPa)	190 - 210
Poisson's Ratio	0.27 – 0.3
Thermal Expansion (10^{-6}/K)	11 – 16.6
Thermal Conductivity (W/m-K)	24.3 – 65.2
Specific Heat (J/kg-K)	450 – 2081
Tensile Strength (MPa)	276 – 1882
Yield Strength (MPa)	186 - 758

2.2.1.1 Low carbon steel

Other name for the low carbon steel is known as mild steel. In recent years, several studies have focused on low carbon steel of mild steel Singh, (2020) according to reports, low carbon steel is the most commonly utilised type of carbon steel. These steels typically have a carbon content of less than 0.25 wt.%, cannot be toughened by heat treatment (to generate martensite). Hence hard work is typically required. Carbon steels are often soft and possess poor strength. However, their high ductility makes them excellent for machining and welding and inexpensive. For example, Rajendran et al., (2020) has described the usage Low carbon steel is frequently used for automobile body parts, structural shapes (I-beams, channels, and angle irons), pipes, construction and bridge components, and food cans. Figure 2.1 shows microstructure on mild steel with the label of pearlite (P) and ferrite (α).

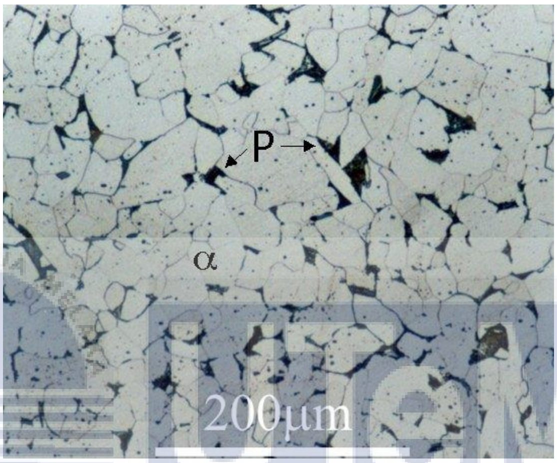

Figure 2.1 Microstructure on mild steel (Sekban et al., 2018)

2.2.1.2 Medium carbon steel

Previous studies have primarily concentrated on carbon steel Singh, (2020) suppose medium carbon steel has a carbon concentration between 0.25% and 0.60% weight and a manganese level between 0.60% and 1.65% weight. This steel's mechanical characteristics are improved by a heat treatment involving austenitization, quenching, and tempering, which results in a martensitic microstructure. However, additional alloying elements, such as chromium, molybdenum, and nickel, can be added to the steel to increase its ability to be heat treated and, therefore, harden. Medium-carbon steels that have been hardened have greater strength than low-carbon steels but at the sacrifice of ductility and toughness. Medium-carbon steels are frequently used for railway tracks, train wheels, crankshafts, gears, and equipment components requiring this mix of qualities due to their high strength, resistance to wear, and tensile strength.

2.2.1.3 High carbon steel

In recent years, several studies have focused on low carbon steel of mild steel Singh, (2020) according to reports, high carbon steel has a carbon content between 0.60% and 1.25% weight and a manganese value between 0.30% and 0.90% weight. It has higher hardness and tensile strength than carbon steel but lower ductility. Because it is virtually always hardened and tempered, high carbon steel is highly wear-resistant. Statement Singh, (2016) due to its extreme hardness and wear resistance, high carbon steel is commonly used for cutting tools that maintain sharp edges and stone nails that can be pushed into concrete or brick blocks without bending, however, due to its brittleness, it tends to break when subjected to excessive stress.

2.3 Surface modification using melting techniques

Researchers have studied about surface modification using melting techniques Amanov, A. and Sasaki, S. (2013) according to the author, the surface hard coating approach has been widely implemented in numerous industries, including automotive, aerospace, and medicinal. In these sectors, engineering components generally function under harsh conditions involving heat, friction, and dynamic motion. As a result, the materials will degrade rapidly, and the component's lifespan will be reduced. A surface coating can enhance a material's tribological qualities by increasing its near-surface hardness, wear resistance, and lowering its coefficient of friction. Surface melting techniques such as laser surface melting and Inert Tungsten Gas (TIG) torch surface melting can be used to apply composite coatings.

2.3.1 TIG torch

Previous studies have primarily concentrated on TIG torch Kumar Das, (2022) it has been stated that tungsten inert gas emission coating is one of the most used methods for coating surfaces. It is often used in coating processes due to its superior metallurgical compatibility between the coating and substrate material, ease of operation, and lower cost than laser-assisted and electron beam assisted coating. Wire feed, powder injection, and pre-coating powder processes are the three methods for putting coating material onto a surface substrate. The feed wire feed process takes the stock material or material to be coated in the forming wire. The wire is delivered to the melting pool through the sidewalls at various angles while the TIG flame remains vertical. After producing coated layer wire smelting on-site, surface materials with strong metallurgical adhesion are used.

2.3.2 Laser cladding

Researchers have studied the laser cladding Zhu et al., (2021) is a procedure that employs manufacturing processes like coating, prototyping, and repair with the production of metallurgical solids can be observed using this method. Liu et al., (2021) summarized that laser cladding is similar to arc welding in that the laser will melt the surface and add material to the surface in the form of a wire, strip, or powder. Frequently, laser cladding can boost the corrosion resistance to the material.

2.3.3 Ion implanting

Previous studies have primarily concentrated on ion implantation Susita & Siswanto, (2107) is a low-temperature technique in which ions from one element are propelled into a dense target, therefore modifying the target's physical, chemical, or electrical properties. If ions halt and remain in the target, they can alter the element's composition if their composition differs from the target's. Ion implants also induce chemical and physical