STUDY ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF QUENCHING AZ31B IN NANO-FLUID

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DECLARATION

I declare that this Choose an item. entitled " Study on microstructure and mechanical of quenching AZ31B in nano-fluid " 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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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 Manufacturing Engineering Technology with Honours.

Signature	:	
Supervisor Name	:	TS. DR. YUSLIZA BINTI YUSUF
Date	:	10/1/2023

DEDICATION

This study is wholeheartedly dedicated to my parent, who have been my source of inspiration and gave me strength and continually provide their moral, spiritual emotional and financial support when I want to give up in doing this study .

To my brother, sister, relative, friends, classmate and housemate who share their words of advice and encouragement to finish this study.

Finally, I dedicated this study to my supervisor Ts .Dr. Yusliza Binti Yusuf who guide me and give some strength to me on doing this study.

ABSTRACT

AZ31B Magnesium Alloy was widely employed in a variety of applications, including automotive, contemporary aircraft fuselages, mobile phone, and laptop casings. This is due to its high strength and flexibility at room temperature, as well as its corrosion resistance and weldability. However, studies indicate that the composition of AZ31B is insufficient to sustain energy absorption, leading this material to fracture. This is owing to the Hexagonal Close-Packed (HCP) structure's low mechanical strength and ductility. Thus, this investigation will explore the impact of Graphene Oxide (GO) as nano fluid quenching medium on the mechanical properties of AZ31B. The AZ31B undergo a 3-hour heat treatment process at the specified temperatures of 250 °C and 350 °C, then immersed for 30 minutes in five different fluid media: air, distilled water, distilled water mixed with 0.1 wt %, 0.3 wt %, and 0.5 wt % of Graphene Oxide to examine the effect of nano fluid media on AZ31B strength. The microstructure analysis was conducted using the Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Spectroscopy (EDX) to observe the surface properties of Magnesium Alloy AZ31B and the presence of GO in varying amounts in the quenching medium.The surface roughness analysis was also carried out to determine the roughness,(Ra)value of AZ31B Magnesium Alloy's after the heat treatment and quenching process done. Besides, the tensile test utilising dog-bone shaped sample was performed to estimate the ultimate tensile strength (UTS), yield strength, and young modulus of AZ31B following the heat treatment and quenching method for mechanical characteristics analysis. From the analysis, result showed that specimen with temperature treatment of 350 ℃ has a smooth surface and low (Ra) value in between 1.869 till 1.964 µm. Besides, the specimen also showed high (UTS),Yield Strength and Young Modulus value in compared to the control sample and specimens that undergo 250℃ as heat treatment temperature. Furthermore, result from the analysis also proved that specimen with various wt % of GO in quenching media affect the microstructure and mechanical properties of AZ31B Magnesium alloy to have a smooth surface and high mechanical properties such as UTS of (250.305 MPa), Yield Strength value of (130.086 MPa) and Young Modulus of (5608.85 MPa) due to the presence of high concentration element Carbon (C) and Oxygen (O).Therefore, this study concluded that specimen with temperature of heat treatment of 350 ℃ followed by sink in Distilled Water + 0.3 wt % GO medium showed is the best parameter to achieve smooth surface and good mechanical properties for AZ31B alloy.

ABSTRAK

AZ31B Magnesium Alloy digunakan secara meluas dalam pelbagai aplikasi, termasuk automotif, fiuslaj pesawat kontemporari, telefon mudah alih dan sarung komputer riba. Ini disebabkan oleh kekuatan dan fleksibiliti yang tinggi pada suhu bilik, serta rintangan kakisan dan kebolehkimpalannya. Walau bagaimanapun, kajian menunjukkan bahawa komposisi AZ31B tidak mencukupi untuk mengekalkan penyerapan tenaga, menyebabkan bahan ini patah. Ini disebabkan oleh kekuatan mekanikal dan kemuluran struktur Hexagonal Close-Packed (HCP) yang rendah. Oleh itu, penyiasatan ini akan meneroka kesan Graphene Oxide (GO) sebagai medium pelindapkejutan cecair nano ke atas sifat mekanikal AZ31B. AZ31B menjalani proses rawatan haba selama 3 jam pada suhu yang ditetapkan 250 °C dan 350 °C, kemudian direndam selama 30 minit dalam lima media bendalir berbeza: udara, air suling, air suling dicampur dengan 0.1 wt %, 0.3 wt % , dan 0.5 wt % Graphene Oxide untuk mengkaji kesan media cecair nano pada kekuatan AZ31B. Analisis struktur mikro juga dijalankan menggunakan Scanning Electron Microscope (SEM) dan Energy Dispersive X-Ray Spectroscopy (EDX) untuk memerhatikan sifat permukaan Magnesium Alloy AZ31B dan kehadiran GO dalam jumlah yang berbeza-beza dalam medium quenching. Analisis kekasaran permukaan adalah juga dijalankan untuk menentukan nilai kekasaran,(Ra) AZ31B Magnesium Aloi selepas proses rawatan haba dan pelindapkejutan dilakukan. Selain itu, ujian tegangan menggunakan sampel berbentuk tulang anjing telah dilakukan untuk menganggar kekuatan tegangan muktamad (UTS), kekuatan hasil, dan modulus muda AZ31B mengikut kaedah rawatan haba dan pelindapkejutan untuk analisis ciri mekanikal. Daripada analisis, keputusan menunjukkan bahawa spesimen dengan rawatan suhu 350 ℃ mempunyai permukaan licin dan nilai (Ra) rendah di antara 1.869 hingga 1.964 µm. Selain itu, spesimen juga menunjukkan nilai (UTS), Kekuatan Hasil dan Modulus Muda yang tinggi berbanding sampel kawalan dan spesimen yang mengalami 250 ℃ sebagai suhu rawatan haba. Tambahan pula, hasil daripada analisis juga membuktikan bahawa spesimen dengan pelbagai % berat GO dalam media pelindapkejutan mempengaruhi struktur mikro dan sifat mekanikal aloi Magnesium AZ31B untuk mempunyai permukaan licin dan sifat mekanikal yang tinggi seperti UTS sebanyak (250.305 MPa), nilai Kekuatan Hasil. daripada (130.086 MPa) dan Modulus Muda sebanyak (5608.85 MPa) kerana kehadiran unsur kepekatan tinggi Karbon (C) dan Oksigen (O). Oleh itu, kajian ini merumuskan bahawa spesimen dengan suhu rawatan haba 350 ℃ diikuti dengan sink in Air Suling + 0.3 wt % GO medium menunjukkan adalah parameter terbaik untuk mencapai permukaan licin dan sifat mekanikal yang baik untuk aloi AZ31B

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LIST OF SYMBOLS AND ABBREVIATIONS

Al	-	Aluminium
Zn	-	Zinc
Mn	-	Manganese
Si	-	Silicon
Cu	-	Copper
HCP	-	Hexagonal Close-Packed
Mg	-	Magnesium
MgO	-	Magnesium Oxide
ASTM	-	American Society for Testing and Material
RHA	-	Rolled Homogeneous Amour
GO	-	Graphene Oxide
EDX / EDS	-	Energy Dispersive X-Ray Spectroscopy
Be	-	Beryllium
Ca	-	Calcium
Sr	-	Strontium
Ra	-	Radium
RE	-	Rhenium
Y	-	Yttrium
Zr	-	Zirconium
C	-	Carbon
O	-	Oxygen
CRSS	-	Critical Resolved Shear Stress
Th	-	Thorium
RE	-	Rare Earth
AZ	-	Aluminium-Zinc
FCC	-	Face Centered Cubic
BCC	-	Body Centered Cubic
SCC	-	Stress Corrosion Cracking
PAH	-	Polycyclic Aromatic Hydrocarbons

rGO	-	reduced Graphene Oxide
Dwg	-	Drawing
SEM	-	Scanning Electron Microscope
mm	-	millimeter
TEM	-	Transmission Electron Microscopy
SCFEA	-	Side Cutting Edge Angle
Ra	-	Roughness Average
Rq	-	Root Mean Square
UTS	-	Ultimate Tensile Strength
E	-	Young Modulus
σ	-	Stress
ε	-	Strain

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CHAPTER 1

INTRODUCTION

1.1 Background

Magnesium Alloy is a combination of Magnesium mix with other metal (alloy) like Aluminum (Al), Zinc (Zn), Manganese (Mn), Silicon (Si), Copper (Cu), Rare Earth Metal and Zirconium to improve the Physical Properties. Magnesium Alloys are the current trend that will be used in US military industry because this alloy is the lightest metallic material that has high potential for weight reduction of Automotive vehicle. The density of magnesium with the value of 1.7g/cm3 is approximately 35% lower than aluminum (2.7g/cm3) and 77% lower than steel (7.9g/cm3) (Mubasyir et al., 2021).

Magnesium Alloy is very suitable in manufacturing Automotive and Aerospace applications. It has an enormous potential for application in the electronics, automobile, and aerospace industries due to their low density and high specific strength. However, this material also has disadvantages too. It has low ductility at room temperature which is related to their Hexagonal Close-Packed (HCP) structure. This scenario has been occurred because there are some gaps/voids that occur between the atoms when all the large atoms are closely pack together in a small area.

Most common Magnesium (Mg) alloy are AZ31B. The word "AZ" stands for Aluminium Zinc Manganese which are the two major alloying elements of the metal. The numbers 3 and 1 indicate the percentage of aluminium and zinc (3 wt.% and 1 wt.% respectively) that had been rounded-off to the whole number while the ''B'' in AZ31B is the second composition which has registered at the American Society for Testing and Materials

(ASTM) (Abdullah et al., 2016). Magnesium Alloy AZ31B normally used in automotive, aerospace, industrial electronic, biochemical, and commercial application because it has high energy absorption capability, high electrical and thermal conductivity, excellent weldability and good castability (particularly for high pressure die casting) (L. Wang et al., 2013).

Magnesium Alloy AZ31B could replace Rolled homogeneous amour (RHA) for armoured vehicle due to its impact behaviour. However, the composition of AZ31B is insufficient to support energy absorption(Salvado et al., 2017). Therefore, to overcome this problem, a quenching method was introduced where the Magnesium Alloy AZ31B with certain temperature will be directly immersed into the medium that consist of nano particle like Graphene Oxide (GO).The nano particle will be able to fill in the void that appear between the large atom to produce van der Waals bonds and prevent structure to be collapse .This will be able to obtain a high energy absorption and AZ31B will not be fracture easily (Abdullah et al., 2016; Mubasyir et al., 2021)

Therefore, this study will be focusing on improving energy absorption through a series of heat treatment and quenching in medium presence of nanoparticle. The characterization will be conducted to determine the suitable combination of composition factors like temperature, and the quenching medium that consist of nanoparticles through Magnesium Alloy AZ31B. Some experiment will be involved to analyse the microstructure and the mechanical properties on Magnesium Alloy AZ31B by using Tensile Test and EDS analysis.

1.2 Problem Statement

Magnesium Alloys such as AZ31B have an immense potential for application in the electronics, automobile, and aerospace industries due to their low density and high specific strength. For example, Magnesium Alloy AZ31B could replace Rolled homogeneous amour (RHA) due to its impact behaviour. However, the composition of AZ31B is insufficient to support energy absorption that will cause this material to be fracture (Salvado et al., 2017).This is because, Magnesium Alloy, AZ31B has low mechanical strength and poor ductility that is related to their Hexagonal Close-Packed (HCP) structure. This scenario has been occurred because there are some gaps that occur between the atoms when all the large atoms are closely attached with each other in a small area.

To solve this problem, a technique such as quenching was introduced. Quenching defines as the soaking of the metal at a hot temperature that above the recrystallization phase, followed by a rapid cooling process to adjust the mechanical properties of its original state to change it become more stronger or weaker than before. Normally, Air, Water, Oil, Liquid Polymer and Brine (combination of water and salt) as quenchant was used (Kresnodrianto et al, 2018).But, conventional quenching has their own Bolling point. For example, water is the common quenchants that been used in forging because its cheap, easy to be manage and has minimal safe handling or disposal consideration. However, when facing hot tool steel or other steel alloys, the absorbed gases within the water tend to bubble out. These bubbles result in softening of the steel with subsequent cracking or warping. Oil has a higher boiling range (230℃ and 480℃) that suitable for high-speed steels and oil-hardened steels. But it has a slower rate of cooling compared to either water or brine, but faster than air, making it an intermediate quench (Thomas, 2019).

Therefore, Graphene Oxide is suitable to be use as the quenching medium because it has high tensile strength (13 MPa) and it easily to be mix with distilled water due to the plenty of oxygen-containing groups in GO (Yuan et al, 2018).

When the hot melting of Magnesium Alloy AZ31B will be directly immersed into the medium that consist of nano particle like Graphene Oxide (GO), the nano particle will be able to fill in the void that appear between the large atom to produce van der Waals bonds and this will be able to obtain a high energy absorption. However, quench process parameter like temperature & nano element composition is crucial to determine. Thus, in this study, a systematic study consisting of the evaluating of quenching that consist of nano particle on various temperature and wt.% of graphene oxide (GO) to have better understanding on the influence of temperature and wt.% to the surface and the mechanical properties of Magnesium Alloy AZ31B.

1.3 Objective

The purpose of this research is to study the microstructure and mechanical Properties of Magnesium Alloy AZ31B after quenching in the medium that contain nano particle. Therefore, the objectives are as follows:

- To evaluate the effect of various temperature of heat treatment and various wt % of Graphene Oxide (GO) medium towards the microstructure and mechanical properties of Magnesium Alloy AZ31B.
- To analyze the microstructure and mechanical properties of Magnesium Alloy AZ31B.

1.4 Scope

The material that will used is Magnesium Alloy AZ31B.It will be cut into Dog-Bone Shaped by referring to ASTM Standard E8-04.Sample for SEM &EDX analysis with dimension of 10mm x 10mm had been prepared during cutting process. Heat treatment process will be conducted on Magnesium Alloy AZ31B with temperature of 250 ℃ and 350 ℃.Specimen 1,3,5,7 and 9 will be heat with temperature of 250 ℃ while specimen 2,4,6,8 and 10 will be heat with temperature of 350 ℃ for 3 hours. The quenching medium that used is combination of distilled water with Graphene Oxide (GO) at various wt % and medium like air and distilled water as control parameter. Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Spectroscopy (EDS or EDX) analysis will be conducted to see the microstructure of Magnesium Alloy AZ31B and the present of Graphene Oxide at the surface of that material to determine whether each specimen consist of Graphene Oxide or not. To know the presence of Graphene Oxide, color mapping was added during Eds analysis. This will easily identify which area contain a lot of Go and which area that had been oxidized. Surface Roughness analysis was conducted to know the surface roughness value of AZ31B Magnesium Alloy after heat treatment and quenching process at 250 ℃ and 350 ℃. Tensile Test will be conducted to test the energy absorption of Magnesium Alloy AZ31B to measure how much it can be deformed before it fractures.

CHAPTER 2

LITERATURE REVIEW

2.1 Magnesium and Its Alloy

Magnesium, Mg is a chemical element, with atomic number of twelve in periodic table. It is a gleaming gray solid with many physical and chemical features that like other five alkaline earth metal which are Beryllium (Be), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). Magnesium can be mixed with other element such as Aluminium, Zinc, Manganese, Silicon, Copper, Rare Earth Metal and Zirconium to produce Magnesium Alloy. The Magnesium Alloy has poor ductility and formability but good fatigue and stress corrosion. Therefore, it was used in manufacturing automotive and aerospace application. It also used for sheet forming process. Figure 2.1 shows the application of Magnesium Alloy in automotive industry (Viswanadhapalli & Raja, 2019).

Magnesium Alloy can be classified into cast alloy and wrought alloy. Cast alloy is the alloy that melted in furnace and poured into mould (die casting) and allow it cool into the specific shape (Traverso, 2020). It can be divided into two group which are Mg-Al alloys that the amount of Aluminium (Al) does not exceed 10% with an addition of Zn and manganese Mn and Magnesium Alloys that free from Al, but mostly contain zinc (Zn), rhenium (RE) and yttrium(Y) with an addition of zirconium (Zr) (Jarka, 2022). Most common cast alloys are AZ63, AZ81, ZK61, HZ32 etc. The proof stress and the tensile stress of magnesium cast alloys was 75–200 MPa and 135–285 MPa.

Wrought alloy is the alloy that worked in the solid form such as forging, extrusion, and rolling operations, to achieve the desired shape with the help of specific tools (Traverso, 2020). The proof stress and the tensile stress of magnesium wrought alloys is typically 160-

240 MPa and180-440MPa. The mechanical properties of magnesium wrought alloys is better than cast alloys because it has high tensile stress and good elongation than magnesium cast alloy (Viswanadhapalli & Raja, 2019). Magnesium wrought alloy can be classified into three basic group. The first group is alloys that contain aluminium, zinc, and manganese. The second group consists of alloys with elements such as Zn, Re, Y, Zr, and Th, while the third group consists of magnesium wrought alloys with ultra-light Li. Figure 2.2 shows the classification of magnesium wrought alloy (Dziubinska & Gontarz, 2015).

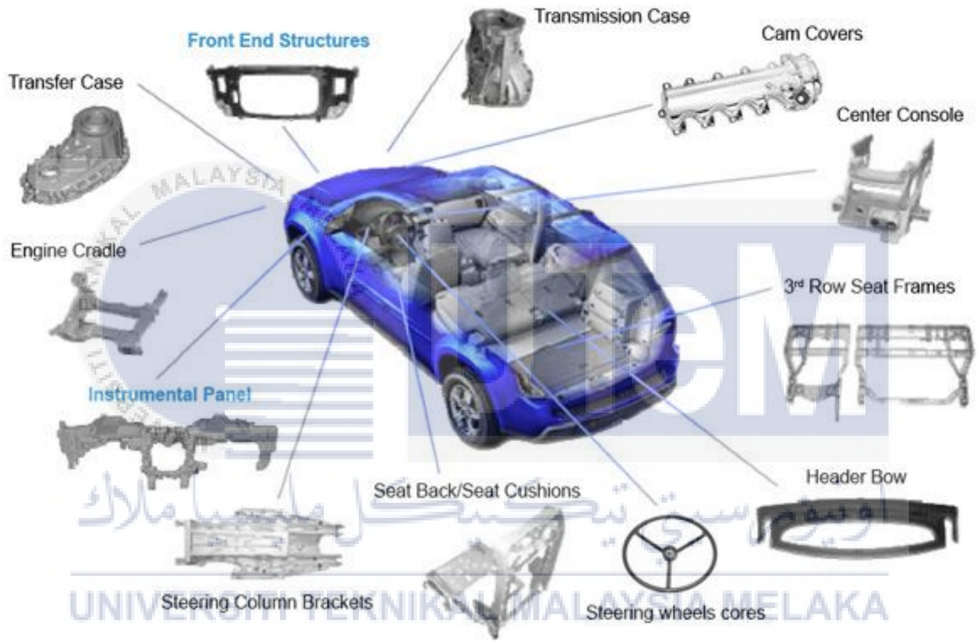

Figure 2.1 Application of Magnesium Alloy in automotive industry.

(Source:<https://www.researchgate.net/publication/337109418_Application_of_Magnesium_Alloys_in_Automotive_Industry-A_Review)