

**STUDY OF EFFECTS OF CRYOGENIC  
TREATMENT ON CASTED AZ80 Mg ALLOY**

**A PROJECT REPORT**

Submitted by

**ASTIN G**

**REG No: TKM21MEIR05**

to

the APJ Abdul Kalam Technological University

in partial fulfilment of the requirements for the award of the Degree

of

*Master of Technology*

*in*

*Mechanical Engineering*

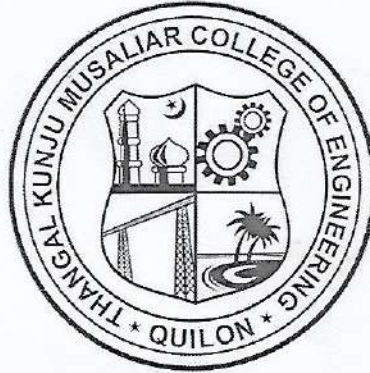
**Specialization: *Industrial Refrigeration and Cryogenic Engineering***



**DEPARTMENT OF MECHANICAL ENGINEERING  
THANGAL KUNJU MUSALIAR COLLEGE OF ENGINEERING  
KOLLAM  
May 2023**

**DEPARTMENT OF MECHANICAL ENGINEERING**

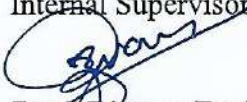
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**CERTIFICATE**

Certified that this report entitled “**STUDY OF EFFECTS OF CRYOGENIC TREATMENT ON CASTED AZ80 MG ALLOY**” is the report of project presented by **ASTIN G.**, Reg. No: **TKM21MEIR05** during **2022-23** in partial fulfilment of the requirements for the award of the Degree of Master of Technology in Industrial Refrigeration and Cryogenics Engineering of the *APJ Abdul Kalam Technological University*.

Internal Supervisor:

  
**Prof. Rizwan Rasheed**

Assistant Professor

Department of Mechanical Engineering

TKM College of Engineering, Kollam-5

PG Coordinator:

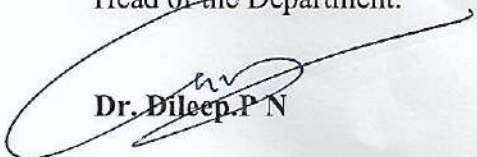
  
**Dr. K.A Shafi**

Professor

Department of Mechanical Engineering

TKM College of Engineering, Kollam-5

Head of the Department:

  
**Dr. Dileep.P N**

Professor & Head

Department of Mechanical Engineering

TKM College of Engineering, Kollam-5

## DECLARATION

I **Astin G**, hereby declare that the project report "Study of Effects of Cryogenic Treatment On Casted AZ80 Mg Alloy", submitted for partial fulfillment of the requirements for the award of degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of **Prof.Rizwan Rasheed**. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma, or similar title of any other University.

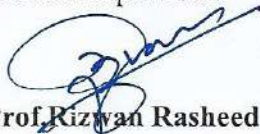


**Astin.G**

Reg No: TKM21MEIR05 of Year 2021-23

MAY 2023

Internal Supervisor:



**Prof.Rizwan Rasheed**

Assistant Professor

Department of Mechanical Engineering

TKM College of Engineering, Kollam-5

Head of the Department:



**Dr. Dileep. P N**

Professor

Department of Mechanical Engineering

TKM College of Engineering, Kollam-5

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## **ABSTRACT**

The Mg & its Alloys are considered to be ‘the green engineering materials of the 21<sup>st</sup> Century. Mg Alloys are light weight , ease of casting and has superior machinability. It has low density, favorable thermal conductivity , specific Strength and Stiffness .AZ80 Mg alloy rectangular Block made by Casting and the effects of various Cryogenic Treatment Such as Rapid Cooling and Rapid Heating etc. on Microstructure and Mechanical Properties has Investigated .Mechanical properties Such as Tensile Strength and Hardness has been Studied. It Shows higher Values of Tensile Strength and Hardness during Rapid Cooling and Rapid heating [RCRH] Cryogenic Treatment Process. Cryotreated AZ80 Mg alloy Shows 8% increase in tensile Strength compared to Untreated condition. Rapid Cooling and Rapid heat Treatment of Mg Alloy was done by heating to 200°C and then cooling to room temperature and kept for 24 hours for aging and then cool to Liquid Nitrogen Temperature. RCRH Cryogenic Treatment Process Shows 30% increase in tensile Strength Compared to Untreated Condition. The Improvement of the mechanical properties of Mg Alloy with Cryogenic Treatment is attributed to the Synergistic effects of the refine grains, twins precipitates and non- basal slip.

**Keywords:** Mg Alloys, AZ80 Mg Alloy, Cryogenic Treatment, Heat Treatment

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# CHAPTER 1

## INTRODUCTION

Magnesium(Mg) alloys are materials that contain magnesium as the primary constituent, with other element added to improve their properties. Mg alloys are popular in various industries because of their low density ,high strength and good castability.

### 1.1. Mg & ITS ALLOYS

Magnesium alloys are mixtures of magnesium and other alloying metal, usually aluminium, zinc, silicon, manganese, copper, and zirconium. Since the most outstanding characteristic of magnesium is its density,  $1.7 \text{ g/cm}^3$ , its alloys are used where light weight is an important consideration (e.g., in aircraft components). Magnesium has the lowest melting point (923 K (1,202 °F)) of all the alkaline earth metals. Pure magnesium has an HCP crystal structure, is relatively soft, and has a low elastic modulus:

There are many types of Magnesium alloys each with its own unique properties and characteristics .Here are some of the most commonly used types

1. AZ31: This is the most widely used magnesium alloy and contains 3% aluminium (Al) and 1% zinc (Zn). It has good formability, and corrosion resistance.
2. AZ91 : This alloy contains 9% Al and 1% Zn, and is stronger and more corrosion resistant than AZ31. It is commonly used in automotive and aerospace applications.
3. AZ61: This alloy contains 6% Al and 1% Zn, and has high strength and good ductility. It is used in applications that require high-temperature strength, such as aerospace and automotive components.
4. AZ80 : This alloy contains 8% Al and 1% Zn. It is known for its high strength-to-weight ratio, good corrosion resistance and excellent castability.
5. Elektron alloys : These are family of magnesium alloys developed by luxfer group and are known for their high strength , low weight and good corrosion resistance

### **1.1.1 APPLICATIONS OF Mg ALLOYS**

1. Automotive Industry: Magnesium alloys are used in various automotive components such as steering wheels, instrument panels, seat frames and engine blocks. The use of magnesium alloys in automotive components helps to reduce the weight of the vehicle and increase fuel efficiency.
2. Aerospace industry: Magnesium alloys are used in aerospace components such as aircraft frames, engine parts. And landing gear. The lightweight properties of magnesium alloys are particularly advantageous in aerospace applications, where weight reduction is critical.
3. Medical industry: Magnesium alloys are biocompatible and can be used in medical implants such as orthopedic screws, plates and pins. They are also used in cardiovascular stents and other medical devices.
4. Electronic devices : Mg alloys can be used in electronic devices due to their excellent electromagnetic shielding properties. They are used in laptop cases ,mobile phone housings and other electronic components.
5. Defense industry : Mg alloys are used in the defense industry due to their ability to absorb impact energy, They are used in armored vehicles, bulletproof vests, and other protective equipment.
6. Sports equipment: Mg alloys are used in the manufacture of sports equipment sych as bicycles, tennis rackets and golf clubs due to their lightweight properties and strength.

### **1.2 PROBLEM DEFINITION**

AZ80 Mg Alloys is mainly used in wheels of automotive after forging deformation. Direct application of as cast AZ80 Mg alloy to product can reduce the cost greatly which is a challenge and has great potential. However the mechanical properties of AZ80 Mg alloy are too low to satisfy the requirement of wheels. Therefore it is important to improve the mechanical properties of AZ80 Mg alloy to achieve the aim. By conducting cryogenic treatment on AZ80 Mg alloy we can improve the mechanical and microstructure properties.

## **1.2 OBJECTIVES**

- 1.** To conduct cryogenic treatment on AZ80 Mg alloy
- 2.** To compare mechanical properties of rapid heating and rapid cooling method and conventional cryogenic treatment Method
- 3.** To compare microstructure properties of Rapid heating and rapid cooling cryogenic treatment and conventional cryogenic treatment method

## Chapter 2

### LITERATURE REVIEW

In this chapter, an overview of the Survey made on past research which has already available has been presented. The main objective of this literature survey is to present the past research on Magnesium alloy. It include work on mechanical as well as microstructure properties of the Mg alloys and thereby identifying the property changes that occur on Mg alloy during various heat treatment abd machining process

In the year 2016, Cui-ju Wang et al, suggested a way to improve the yield strength and ultimate strength of Mg alloy [AZ91]. The AZ91 alloy containing (“AC”) and without (“AS”)  $Mg_{17}Al_{12}$  phase were both subject to hot extraction at 693K with the extrusion ratio of 16:1. Results showed that the pre-existed  $Mg_{17}Al_{12}$  phase in “AC” alloy led to finer grain size and lower intensity of basal plane texture as compared with “AS” alloy . The Ultimate strength and Yield strength increase by the second phase precipitation.

In 2012, Jun-wei FU et al, shows the influence of Nd addition on the microstructures and mechanical properties of AZ80 magnesium alloys . The results show that the microstructure of as-cast AZ80 magnesium alloy is modified effectively with the addition of 1.0% Nd, the grain size is decreased from 448 to 125 $\mu$ m, new rod-shaped  $Al_{11}Nd_3$  phase and block-shaped  $Al_2Nd$  phase are observed in the as-cast microstructure, and  $\beta$ - $Mg_{17}Al_{12}$  phases are refined and become discontinuous, The addition of Nd suppresses the discontinuous precipitations at grain boundaries during aging and the time reaching the peak hardness is delayed.

In 2022 , Bo che et al, investigated the microstructure and mechanical properties of AZ31 Mg alloy prepared by a novel process combining hot rolling and various cryogenic treatments. The results shows that twins and the  $Al_8Mn_5$  phases were introduced in the Sample with rapid heating and rapid cooling and slow heating and slow cooling, which can significantly impede the movement of dislocation, while twins also can effectively coordinate deformation.

R,Bertolini et al (2022), shows that cryogenic machining can represent a promising approach to enhance the poor corrosion fatigue behavior of the AZ31 magnesium alloy. The work deals with the analysis of the influence that different machining strategies may have on the corrosion fatigue performance of the AZ31 magnesium alloy. To this aim, cryogenic and dry machining operations were carried out, and the machined samples were then subjected to corrosion fatigue tests in a physiological environment at different imposed stresses, namely 100MPa, 110MPa and 120MPa.

Mohd Danish et al.(2016) shows that cryogenic machining has induced beneficial surface integrity and quality that not only helps on improving the corrosion resistance but also enhance its sustainability and reduce ignition risk. It investigates the influence of cryogenic machining of AZ31 C magnesium alloy on several critical surface integrity parameters (surface roughness, crystallographic planes, microstructures and microhardness).

Kai Zhang et al (2020) shows a systematic investigation into the deformation structures in Mg alloys during the rolling process from RT to cryogenic temperature and provides insights into the newly discovered twinning sequence and twin-twin interactions. In this study AZ31 samples are rolled to various thickness at room temperature and cryogenic temperatures. It identify and analysis the twinning interaction and their sequence in detail, integrating the understanding.

Hui TAO et al (2022) Studied the evolution of precipitates and mechanical properties of AZ80A magnesium alloy with aging time using SEM, TEM &Tensile test. It shows that continuous precipitation (CP) phases near the reaction front (RF) are replaced by the discontinuous precipitation (DP) phasrs at the early aging stage. In DP regions, the elliptical phases coarsen obviously with the increase of aging time, which results in a slightly slow reduction of the intracrystalline hardness of DP regions.

Chengxuan Yin et al (2023), studied the microstructure and tensile properties of the sample in traveling direction and pass overlap direction of AZ91 Mg alloy were analyzed, The sample was composed of equiaxed grains, The grain size was homogenous in the deposited passes, while there was an obvious difference of grain size in the junction area of the deposited passes.

Cong Dang et al (2023), shows the effect of the lamellar long period stacking order (LPSO) phase on both mechanical properties and damping capacity of magnesium alloy. The lamellar LPSO phase has used as a functional phase to enhance the damping capacity and mechanical properties at the same time, and provide news ideas about preparing high-strength and high-damping magnesium alloy.

Dewang zhao et al (2023) shows ultrasonic welding between AZ31B magnesium and pure copper is carried out, The fracture, microstructure and tensile properties of the joint is studied, and its connection mechanism is analyzed. The finite element analysis model of magnesium copper ultrasonic welding process is established, the accuracy of the model is verified, and the distribution of temperature field and phase deformation field were

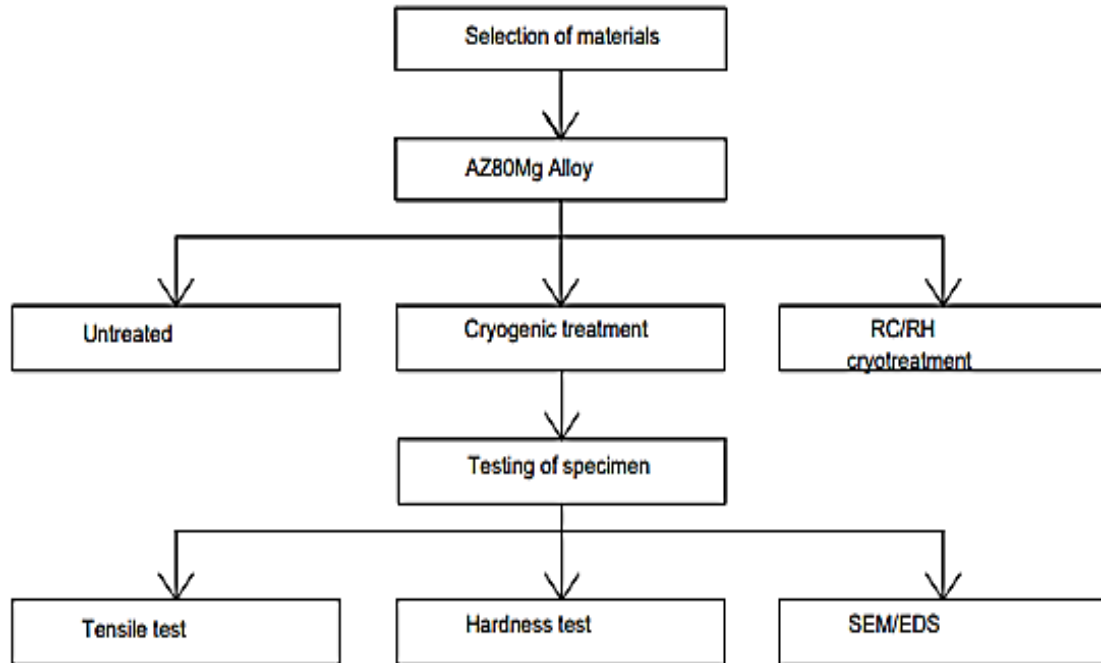
studied.

Xin che et al, (2023) shows the deformation behavior, microstructure and mechanical properties of AZ80 alloy with modified open punches during rotating backward extrusion. This results showed that increasing groove numbers effectively improved the accumulative strain and re alloying element alloying sulted in lower deformation load. The mechanical properties has significantly improved with the groove increasing and microhardness of open punch was considerably improved.

## **2.1 SUMMARY**

Recent research on magnesium alloys has focused on various aspects, including the addition of alloying elements, modification of microstructure, cryogenic treatments and welding techniques. Studies have shown that the addition of second phase particles such as  $Mg_{17}Al_{12}$ ,  $Al_{11}Nd_3$  and  $Al_2Nd$  can significantly improve the yield strength and ultimate strength of magnesium alloys. Cryogenic treatments have been found to introduce twins and  $Al_8Mn_5$  phases, which impede the movement of dislocations and coordinate deformation. Cryogenic machining has also found to enhance the corrosion resistance and sustainability of magnesium alloys. Research on deformation behavior and microstructure during rolling and extrusion processes has provide insights into twinning sequence and twin- twin interaction. Furthermore, the use of LPSO phase has been found to improve both mechanical and damping capacity in magnesium alloys. Overall, recent research has provided valuable insights into improving the properties of magnesium alloys.

## CHAPTER 3 METHODOLOGY



### 3.1 SELECTION OF MATERIAL

AZ80 Mg alloy that contains 8.5% Al and 0.5% Zn by weight. It is a high-strength alloy that exhibits good corrosion resistance and is commonly used in applications that require lightweight, high-strength materials. The addition of Al to Mg in AZ80 increases its strength and hardness, with the addition of zinc improves its creep resistance. This makes AZ80 a popular choice for applications such as aerospace components, automotive parts and sporting goods. One of the main advantage of AZ80 is its high strength-to-weight ratio, which makes it and ideal material for light weight applications. However, magnesium alloys like AZ80 and also known to be susceptible to corrosion, particularly in harsh environments. Therefore, protective coatings or surface treatments may be necessary to enhance their corrosion resistance.

Overall, AZ80 is a high-performance magnesium alloy that offers a unique combination of strength, lightness and corrosion resistance, making it a popular choice for a variety of application



Fig 3.1 AZ80 rectangular block

### 3.2 CRYOGENIC TREATMENT

Cryogenic treatment is a process in which materials are subjected to extremely low temperatures in order to modify their physical and mechanical properties. This process involves cooling materials to temperatures below  $-150^{\circ}\text{C}$  for an extended period of time, typically several hours of days.

The main goal of cryogenic treatment is to improve the strength, durability, and wear resistance of materials by inducing changes in their microstructure. During the cooling process, the materials undergo a transformation in which residual stresses are relieved and the structure become more uniform, resulting in improved mechanical properties. Cryogenic treatment is commonly used in the automotive, aerospace and manufacturing industries to enhance the performance of various components such as engine parts, cutting tools, and gears. It has also been used to improve the acoustic properties of musical instruments and to increase the lifespan of electronic components



Fig 3.2 Setup of Cryogenic treatment

Fig 3.2 represents Setup of cryogenic treatment consists of DAQ , Cryobath and thermocouple. Data Acquisition(DAQ) refers to the process of collecting data from various source and converting it into a form that can be analyzed and stored by a computer or other electronic device. DAQ systems typically consist of sensors or transducers that

are used to measure physical or electrical signals, such as temperature, pressure, voltage or current. These signals are then amplified, filtered, and converted into digital signals that can be processed by a computer or data logger.

T-type thermocouple is a type of temperature sensor that is commonly used to measure temperatures in the range of  $-200^{\circ}\text{C}$  to  $+350^{\circ}\text{C}$ . It consists of two dissimilar metal wires, usually Cu and constantan that are welded together at the measuring end to form a junction.

### 3.3 RAPID HEATING AND RAPID COOLING

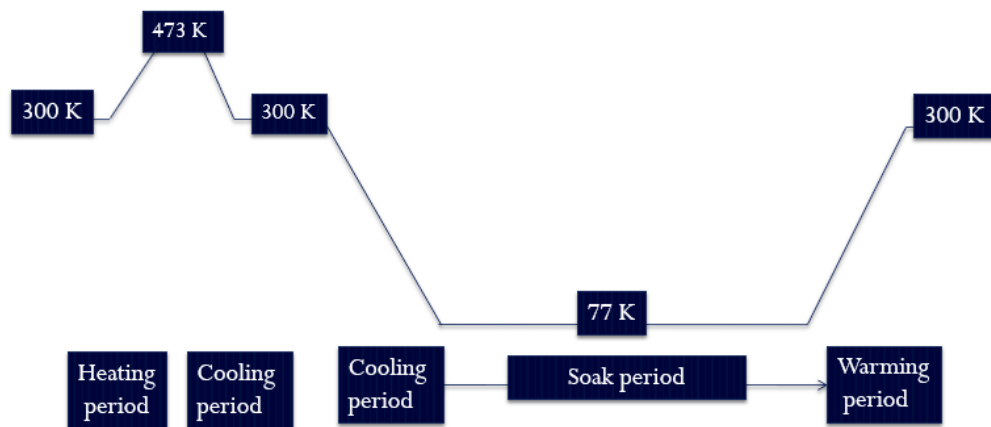


Fig 3.3 Schematic diagram of RCRH cryogenic treatment method

Schematic diagram of Rapid cooling and rapid heating refer to processes of quickly increasing or decreasing the temperature of a material or components. These processes can have a significant impact on the properties of the material or component, and are commonly used in manufacturing and material processing,

#### STEPS IN RCRH CRYOGENIC TREATMENT METHOD

1. Rapid heating
2. Rapid cooling
3. Pre cooling
4. Deep cooling
5. Soaking
6. Warming up

## 7. Post treatment

1. *Rapid heating* : Rapid heating refers to a process in which a material is heated quickly to a high temperature by a resistance furnace. A resistance furnace is a type of electric furnace that uses the resistance of a material to generate heat. In this experiment , it is heated to a temperature of 200°C.
2. *Rapid cooling* : Rapid cooling, also known as quenching, can have significant effects on the properties of a material. Here a material is rapid cooled from a high temperature is microstructure can change, resulting in alteration to its properties. It takes 1 minutes to rapid cool.
3. *Pre-cooling* : The material was treated in a Pre cooling chamber where it was cooled to a pre cooled to a temperature of around -40°C using LN<sub>2</sub>.
4. *Deep cooling* : The specimen was then transferred to a deep cooling chamber where it was cooled to a temperature of 160°C for 24hrs.
5. *Soaking* : The material was then held at the deep cooling temperature for a period of 24hrs or a day.
6. *Warming up*; After the soaking period, the material was gradually warmed up to room temperature over a period 2 hrs .
7. *Post treatment* : Finally the material was then inspected and tested to ensure that it has undergone the desired change in its physical properties . The tests that conducted were Hardness test , Tensile test and SEM/EDS analysis.

## 3.4 TESTING OF SPECIMEN

### 3.4.1 TENSILE TEST



Fig 3.4 Tensile testing setup

A tensile test , also known as tension test used to determine the mechanical properties of a material under tensile load. The test involves applying a controlled tensile force to a sample of the material until it breaks, while measuring the elongation and the corresponding load. The resulting stress – strain curve obtained from the test provides valuable information about the material behavior under tensile loading. During tensile testing , a sample of the material is placed between two clamps of a testing machine, and an axial force is applied to one of the sample, while the other end is fixed. It is shown in the fig3.4 As the load is increased, the sample elongates and the cross sectional area of the sample decrease due to necking. The applied force and the elongation are measured continuously throughout the test., and the corresponding stress and strain are calculated. Here untreated and Cryo treated specimen were tested for tensile strength in UTM according to the standard ASTM B557M-07 ( 200mm×100mm× 15mm). Tensile test were performed on a CMT 5105 UTM at a rate of  $10^{-3}s^{-1}$ . Here we get values of load and displacement, by the equation ,  $\text{Stress} = \text{Force}/\text{area}$  . We get stress.

### 3.4.2 HARDNESS TEST



Fig 3.5 Rockwell hardnes setup

The Rockwell hardness test is a method of measuring the hardness of a material. Fig 3.5

shows experimental setup in order to find out the hardness of a material. The rockwell hardness test involves indenting the material with a diamond cone or steel ball and measuring the depth of penetration. The hardness is determined by measuring the depth of penetration . The hardness is determined by measuring the difference between the depth of the initial indentation made with a smaller load. The rockwell hardness is often preferred over other hardness testing method because it is relatively easy to perform and can provide accurate and repeatable results. It is commonly used in manufacturing meet required hardness specification. The rockwell hardness value is expressed as a number followed by a letter such as HRB or HRC. The number indicates the hardness value on the Rockwell scale, while letter indicates the type of indenter and the load used for the test. In this experiment, ball indenter is used so the values expressed in HRB.

### 3.4.3 SEM& EDS ANALYSIS

SEM stands for Scanning electron Microscope. It is a type of microscope that uses a focused beam of electron to image the surface of a sample, SEM are widely used to investigate the microstructure of material at high magnifications,. The principle of operation of an SEM is based on the interaction between electrons and the sample, The electron beam is focused on to the sample using a series of electromagnetic lenses. As the beam interacts with the sample, some of the electrons are scattered, while the others are absorbed or backscattered. These interaction generate signals such as secondary electrons, backscattered electrons and X-ray, which are detected and used to form an image of the sample surface.

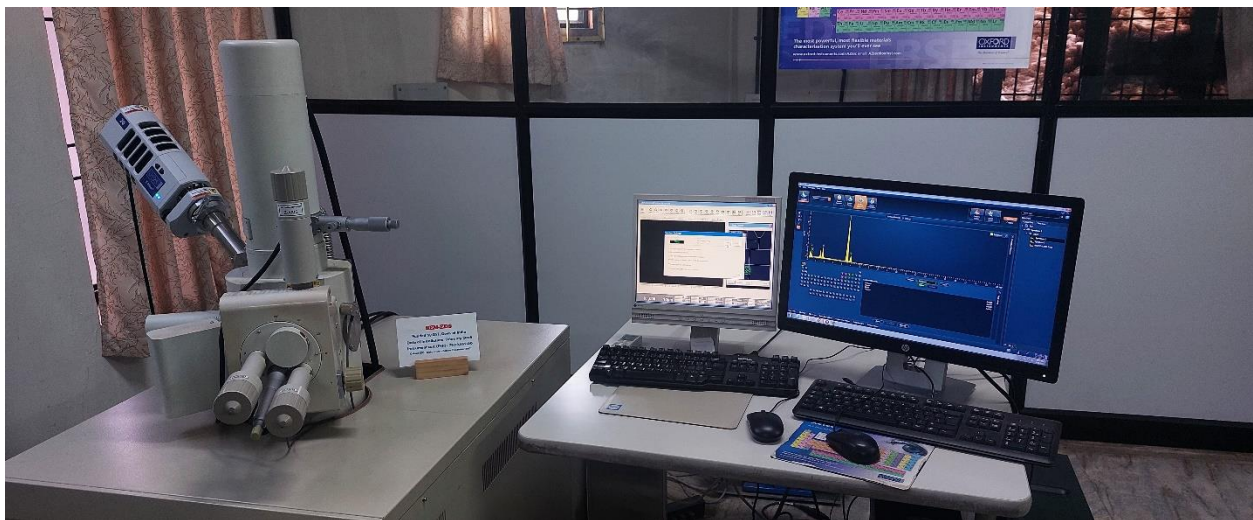


Fig 3.6 SEM analysis

EDS analysis or Energy Dispersive X-ray Spectroscopy analysis , is a technique used in conjunction with Scanning electron microscope (SEM) to determine the elemental composition of a specimen, EDS analysis work by detecting and measuring the energy of X-ray emitted by a sample as a result of electron beam excitation.

During an EDS analysis , the SEM generates an electron beam that is focused onto the sample surface. As the beam interacts with atom in the sample, it knocks electrons out of their orbit, creating vacancies. When electrons from higher energy level fill these vacancies, they emit X-ray are then detected and measured using an EDS detector, which convert the X-ray energy into an electrical signal.

The resulting EDS spectrum provides information about the element present in the sample and their relative abundances. EDS analysis can be used to detect element ranging from boron to uranium, with detection limits depending on the type of sample and the analytical conditions.

In order to conduct these test, Specimen should be in the size 5mm×5mm× 5mm. EDM (Electric discharge machining ) is used to the cut the specimen to required specification. It uses a spark discharge to remove material from workpiece. The process involves creating an electric discharge between an electrode and a conductive workpiece, which erodes the material in a controlled manner. In EDM , a tool electrode made of a conductive material ( usually copper or graphite) is used to shape the workpiece by creating sparks between the electrode and the workpiece . The tool electrode and the workpiece are separated by a small gap and a dielectric fluid is used to cool and flush away the eroded material. There are mainly two types of EDM, they are



Fig 3.6 Wire EDM

EDM was used to cut the specimen for SEM analysis. The process shown in the fig 3.6 . A thin wire is used as the electrode to cut through a conductive material. The process involves passing an electric current through the wire and the work piece , creating a series of sparks that erodes the material to produce the desired shape. The wire electrode used in wire EDM is typically made of a thin , metallic wire such as brass or tungsten . The wire is guided along along a pre-programmed path by a computer controlled system, which ensures that the wire cuts through the material to the required depth and shape. During the wire EDM process, an electric current is passed through the wire and workpiece, creating a sense of sparks that erode the material to produce the desired shape.

## CHAPTER 4

### RESULTS AND DISCUSSION

Cryogenic treatment significantly improve the microstructure and properties of AZ80 magnesium alloy including its hardness , tensile strength etc. These improvements make AZ80 magnesium alloy a more suitable material for high stress application in industries such as aerospace, automotive and defense.

#### 4.1 Mechanical properties

##### 4.1.1 Tensile Strength

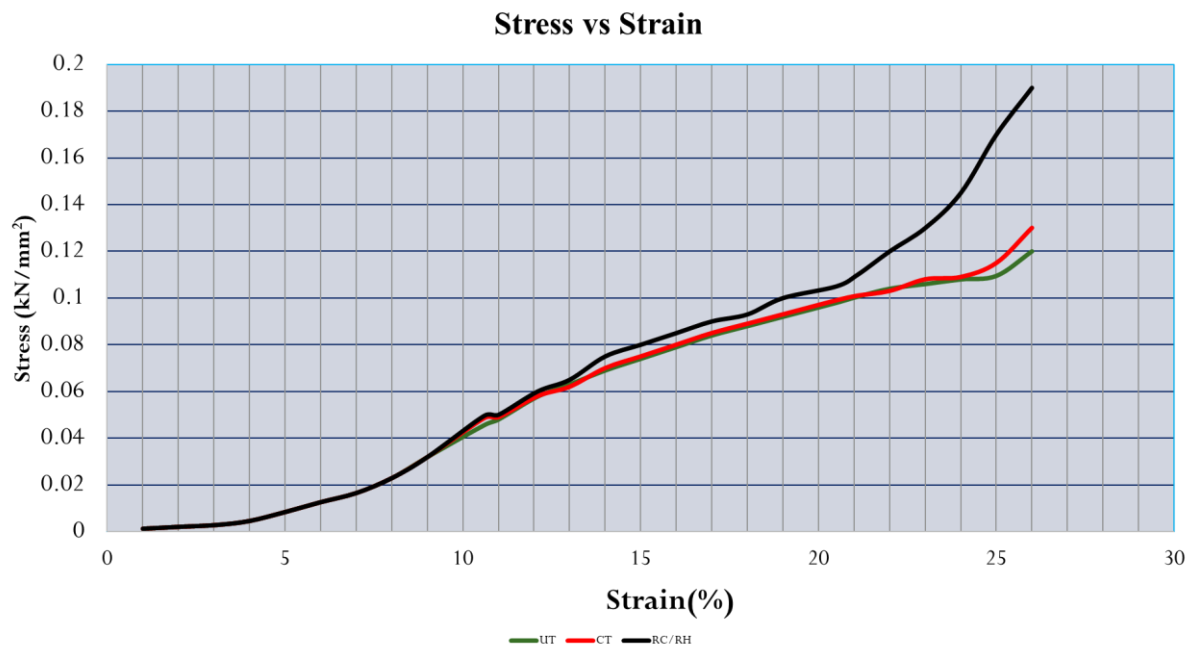


Fig 4.1. the true stress-true strain curve of AZ80 Mg alloy

Fig 4.1 shows that tensile strength of the sample with RCRH cryotreatment than that of the conventional Cryotreatment and without cryotreatment. It is observed that a 10% increase for RCRH sample than conventional cryotreated sample and also a 30% increase in RCRH sample compared to the untreated sample. The RCRH method make the temperature of the alloy change sharply, resulting in a great change in the microstress inside the alloy, thereby causing a large number of dislocation. Tensile strength increase with decrease in temperature , The tensile strength depends on the movement of dislocations. At lower temperature the internal energy of atom is low. It is presumed that as a result , the atoms of the material vibrate less vigorously with less thermal agitation. When these agitation are low , the movement is hampered, So it requires a very large

stress to tear the dislocation from the equilibrium position.

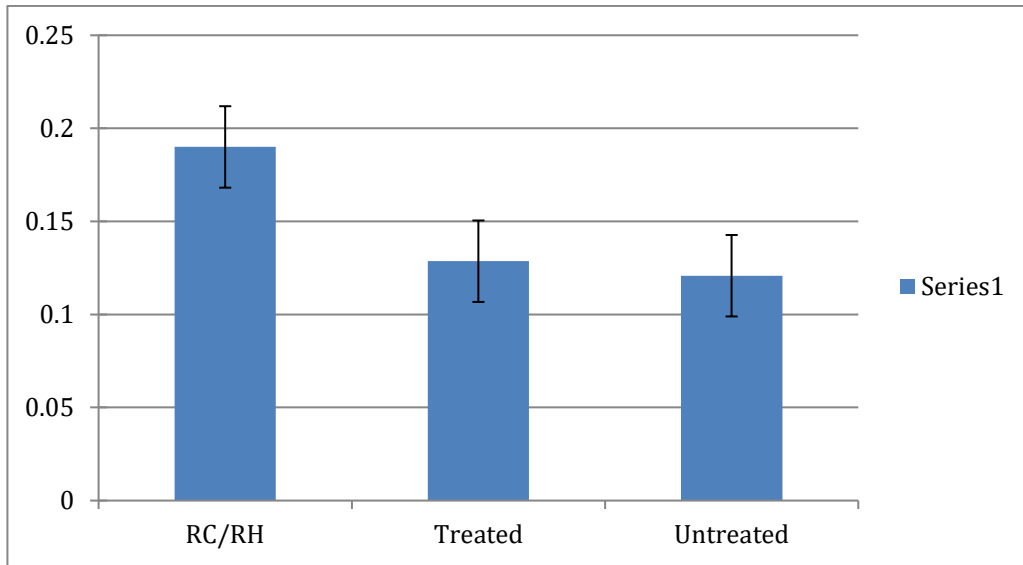


Fig 4.2 Error analysis

<i>Untreated</i>	<i>Treated</i>	<i>Rcrh</i>	<i>Avg</i>	<i>Stdev</i>
0.19	0.195	0.185	0.19	0.007906
0.132	0.129	0.127	0.1286	0.002702
0.119	0.125	0.122	0.1208	0.002482

Table 4.1 Error analysis

Error analysis of 5 samples is shown in fig 4.2. in the table 4.1 , The maximum values of stress in three condition such as RCRH sample , Conventional Sample and untreated sample. For RCRH sample , the average true stress value is  $0.19\text{kN/mm}^2$ . For treated sample, average value is  $0.1286\text{kN/mm}^2$ . For untreated sample, the average value is  $0.1208$ .

#### 4.1.2 HARDNESS

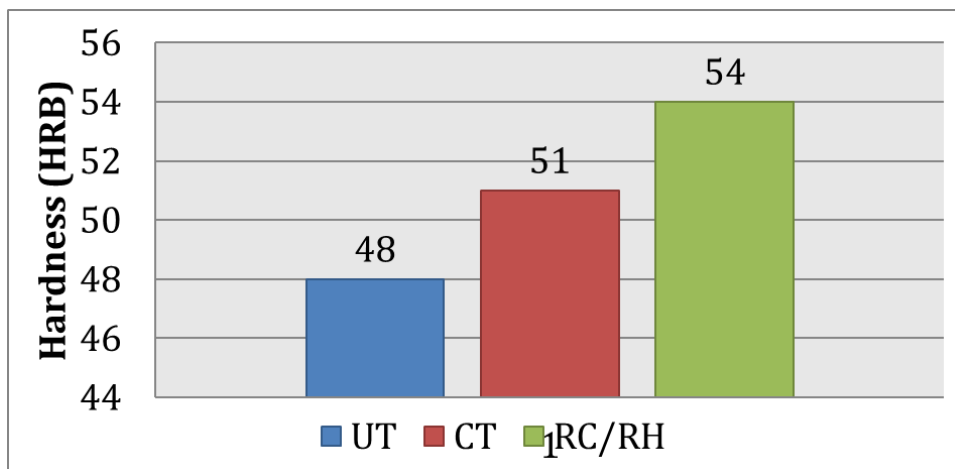


Fig 4.3 . Hardness value

Fig 4.2 shows hardness values of different samples such RCRH cryotreatment ,

Cryotreated and without cryogenic treatment. RCRH cryotreated, normal cryotreated , without cryogenic treatment. It shows 5% increase in Hardness value for RCRH sample than conventional cryotreated sample. For RCRH cryotreated sample shows 10% increase in hardness than untreated sample. This increase in hardness is attributed to the refinement of the microstructure , as well as the precipitation of the intermetallic particles during the cryogenic treatment process. The effect of cryogenic treatment on the hardness of a material can vary depends on the specific material and its processing history. Cryogenic treatment on the hardness result in a modest increase in hardness.

## 4.2 MICROSTRUCTURE

### 4.2.1 SEM analysis

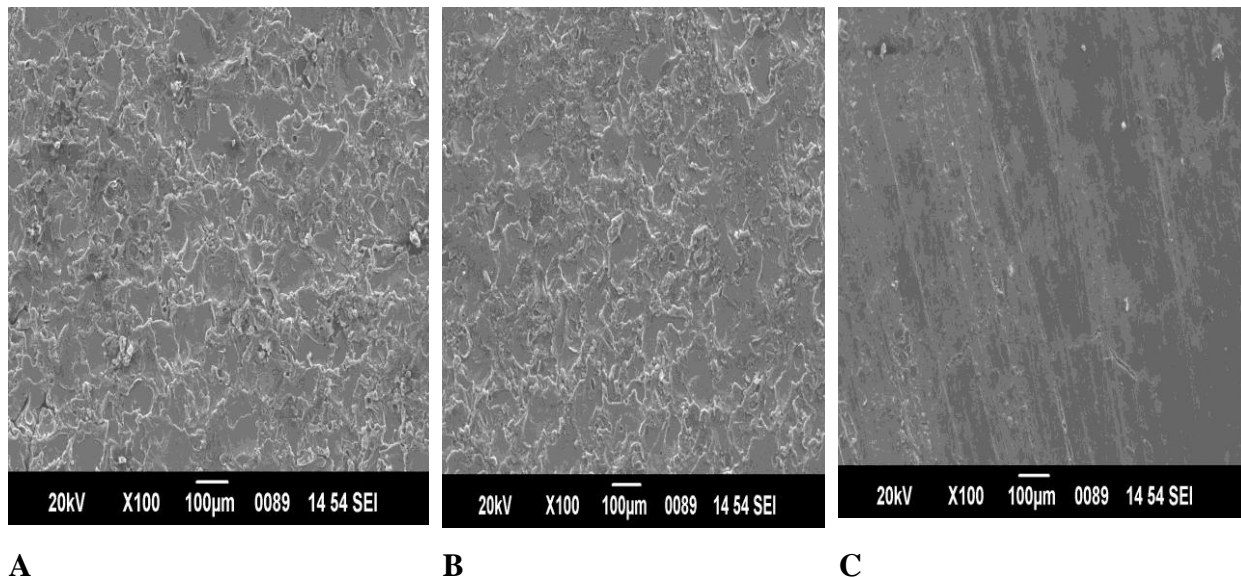


Fig 4.4 SEM images of AZ80 Mg alloy with various condition A. Untreated B, Treated C. RCRH

Microstructure of AZ80 Mg alloy with various cryogenic treatment is shown in the figure fig 4.4. From the fig 4.4 we can see that for RCRH cryogenic treated sample a fine structure is found. Grain size is decreased , decrease the amount of possible pile up at the boundary, increasing the amount of possible pile up at the boundary , increase the amount of applied stress necessary to move the dislocation across a grain boundary.

During subsequent heat treatment , the dislocation can be removed by annealing, resulting in a refined microstructure and a reduction in the grain size of the material. The reduction

in grain size of a material. The reduction in grain size due to the formation of new, smaller grains during the recrystallization process, which occurs when the dislocation are removed.. Grain Size of RCRH sample is  $50\mu\text{m}$  . and the treated grain size is  $76\mu\text{m}$ .

#### 4.2.2 EDS Analysis

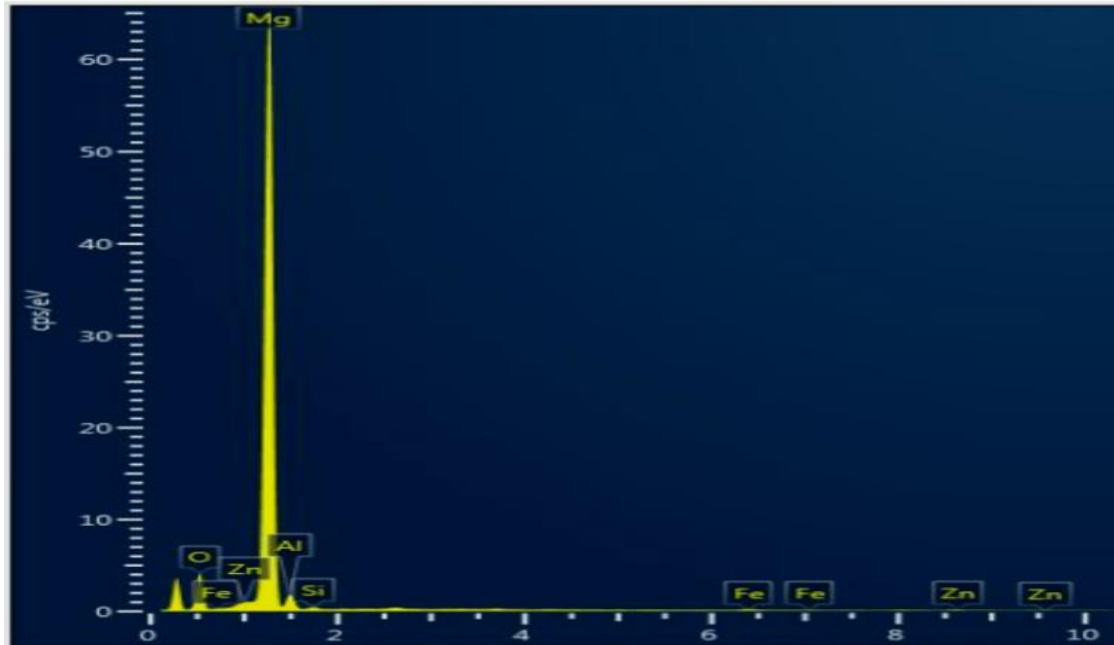


Fig 4.5 EDS image of AZ80 Mg alloy

Element	wt%
Magnesium	77.08
Oxygen	15.1
Aluminum	5.53
Silicon	0.6
Iron	0.62
Zinc	1.07

Table 4.2. Composition of elements

The composition of the specimen is specified in the fig 4.5 and Table 4.2 . The composition of specimen are magnesium ( 77.08) , Oxygen ( 15,1%) , Al ( 6.53) , Silicon ( 0.6)., Iron ( 0.62) and zinc (1.07).

## **CHAPTER 5**

### **CONCLUSION**

The purpose of the research was to investigate the effects on mechanical properties and morphology of AZ80 Mg alloy on Deep cryogenic treatment, rapid heating and rapid cooling cryogenic treatment. On Rapid heating and rapid cooling , tensile strength is increased by 30% compared to the untreated sample . 10% increase in tensile strength on RCRH cryogenic treatment method compared to the normal cryogenic treatment method. Hardness value also increase during RCRH cryogenic treatment method, For RCRH cryogenic treatment method , hardness value is increased by 10% and 5% compared to the treated and untreated sample. During RCRH cryogenic treatment , the grain size is less compared to the Cryotreated and untreated sample. By RCRH Cryogenic treatment method we can improve the mechanical properties and microstructural properties. So we can use AZ80 Mg alloy for application such as automotive, aerospace and defense.

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