MICROSTRUCTURE AND PROPERTIES OF AE42 MAGNESIUM ALLOY AND ITS COMPOSITE

A THESIS SUBMITTED FOR THE DEGREE OF

B.Tech in Metallurgical and Materials Engineering

By

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CERTIFICATE

This is to certify that the work in this thesis report entitled "**Microstructure and properties of AE42 magnesium alloy and its composite**" which is being submitted by **Yudhistir Kumbhar** (Roll no:**110MM0361**) of B.Tech, National Institute of Technology, Rourkela has been carried out under my guidance and supervision in partial fulfillment of the requirements for the degree of Bachelor of Technology in Metallurgical and Material Engineering and is bonafide record of work.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

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ABSTRACT

Metal Matrix Composite (MMC) has got so many applications in automotive and aerospace industries due to their high strength. The AE42 magnesium alloy have high creep resistance in the range in a low temperature range and AE42 + 20% saffil that can perform in higher temperature range above 200°C .weight reduction in automotive industries will result in considerable economic advantage. And due to the presence of huge casting in power-train, also the significant mass in front of the vehicle, high temperature magnesium alloys that meets the service requirements of these components which are under investigation. During the course of the study, the amounts of particular phase fractions from the integrated intensity of XRD results have also been calculated . Magnesium is lightest of all metals used as the basis for constructional alloys and due to this property which entices automobile manufacturers to replace denser materials, cast irons , steels and copper base alloys and even aluminum alloys by magnesium based alloys.

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INTRODUCTION

In automobile industries now a days main emphasis is on reducing weight and which is itself promoting magnesium alloys. Magnesium is one third-less and fourth-fifths less dense then aluminum and iron. Magnesium alloy have easy castability than aluminum. Metal Matrix Composite (MMCs)are the very keen interest in the recent years because of their varied application in various field of technology .

In AE42 magnesium alloy (where 4% aluminum, rare earth is 2%, and rest is balance by Magnesium). It is becoming attractive candidate for its application in automotive, audio, electronic and aerospace industries. They earn the reputation owing to their high specific strength. This also foreseen that the

Mg-based MMCs can become a suitable replacement for Al-MMCs.

for temperatures 200 °C and above, metal matrix composites (MMCs) need to be developed. For deterioration of the creep properties Particulate reinforced Mg-MMCs might actually do and operating at high temperature above 200°C.

by comparing the microstructure and properties in as-cast condition and the behavior of AE42 magnesium alloy and its composites fiber reinforced with 20% Al_2O_3 .

LITERATURE REVIEW

Now a days casting magnesium alloys has been significantly advance over the past few years initially controlling rapid alloy oxidation, optimization and development to meets specific requirements were undertaken and overcome. But then magnesium alloy shows excellent castability.

THE ADVANTAGE OF MAGNESIUM ALLOY

1. Lowest density of all structural materials
2. High specific strength
3. It has Good castability which suitable for high casting
4. It can be turned at high speed
5. By using high purity mg alloy we get improved corrosion resistance
6. This is readily available.
7. By comparing with polymeric materials

    It has better mechanical properties

    It can be recyclable

THE DISADVANTAGE OF THE MAGNESIUM ALLOY

1. Low elastic modulus.
2. Limited toughness.
3. Its strength and creep resistance at elevated temperature is limited.
4. It has high chemical reactivity.
5. Limited corrosion resistance in some application.

METAL MATRIX COMPOSITE

Metal Matrix Composites (MMCs) a composite material are being metal and other material may be a different metal or another material. Because of their extensive application in automotive, aerospace and other structural applications it's a keen subject of interest in recent years. Light weight and better properties with easy availability of reinforcements gives reproducible properties. As the Metal matrix composite combine the metallic properties as ductility and toughness along with the properties like strength and modulus which are ceramic properties.

Metal Matrix Composite can be categorized according to what reinforcement is used on the matrix. Early the continuous fiber reinforced with mostly aluminum and copper matrices based on early study. Despite the high level properties, problems associates with this are mainly are high manufacturing cost associated with some type of a reinforcements that will give high end properties and high intensive worker. As particle reinforced Mg-MMCs this might actually deteriorate the creep properties. Short fiber reinforced metal matrix composite has to be developed for these type of application.

We cannot ensure all properties by conventional alloying practices. So for this we have to use fiber and practice reinforcement. Al_2O_3 , SiO_2 or carbon are the reinforcement we used the most. And the main aim is to improve the elastic modulus and also were and creep resistance. It is also possible to modify the thermal expansion. Only problem arise because of the reactivity of the magnesium. And because of the attack it impair the reinforcement. So primary aim is to identify an appropriate matrix alloy in this area of development.

MATERIAL AND EXPERIMENTAL PROCEDURE

MATERIALS:

1. AE42 Magnesium Alloy and
2. AE42 + 20% Saffil Short Fiber

The composition of the AE42 magnesium alloy is shown in table below.

Table no. 2: Composition of the AE42 alloy

Magnesium	94%
Aluminium	4%
Rare earth	2%
1.lanthanum	0.6%
2.cerium	1.2%
3.neodymiun	0.4%
4.thorium	0.6%
5.praseodymium	0.1%

The AE42 alloy is reinforced with 20% Saffil (delta-Al_2O_3) short fiber and the properties of this short fibre is shown in following Table.

TABLE NO. 1: **The chemical composition and properties of saffil fiber**

Chemical Composition (wt%)	**melting temperature (°C)**	**effective temperature (°C)**	**tensile strength (Mpa)**
Δ- Al_2O_3 (96-97)	above 2000	above 1600	2000
SiO_2 (3-4)			

Young's modulus (Gpa)	**density (gm/cm^3)**	**mohr's hardness**
300	3.3	7

MATERIAL PREPARATION

1. Sample cutting
2. Surface sizing
3. Paper polishing
4. Diamond polishing
5. Final finishing mirror image using etchant for microstructure observation (etching)

OPTICAL MICROSCOPE :-

Figure 1

Under computerized optical microscope Microstructures of the compression samples were observed . in etched conditions Characterization is done.

And than The micrographs of the samples were observed and abtained

SCANNING ELECTRON MICROSCOPY (SEM) :-

Figure 2

Using standard metallographic techniques samples were mechanically polished before the examination.

And in etched conditions Characterization is done.

X-RAY DIFRACTION TECHNIQUE

Figure 3

Samples were subjected for XRD analyses at 30 kV and 20 mA . using Cu Kα radiation

Than the X-ray scan parameters were used are as follows:

Scanning angle is 10 to 100 deg of 2θ

2 degree step size for scanning

1 minute is the time per step

HARDNESS TESTING :-

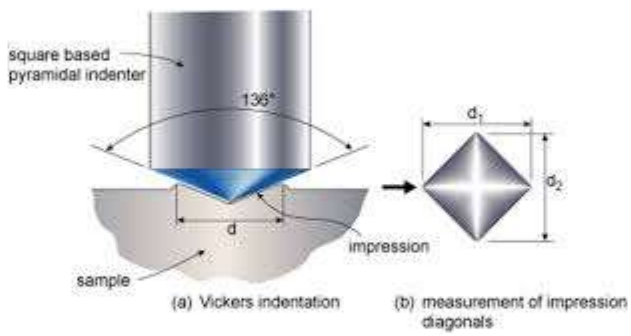

Figure 4.1 & 4.2

The two sample were polished using different size of emery paper and cloth polished also the vicker's hardness of the final polished samples were measured by indentation test, with square base diamond base indenter which under the application of 5kg load with a dwell time of 10sec .then the diagonals of the indent formed on the material surface (both alloy and composite) were measured then the hardness was calculated based on the following relation

$$\text{vicker's hardness } \mathbf{(HV) = \ 1.854\ p/d^2}$$

Where

HV is the vicker's hardness

p is the load applied

d = (d1+d2)/2 "d1 is dimeter of diagonal 1 and d2 is diameter of diagonal 2"

RESULTS AND DISCUSSION

OPTICAL MICROSCOPY

SCANNING ELECTRON MICROSCOPY

X-RAY DIFRACTION AND PHASE ANALYSIS

HARDNESS

OPTICAL MICROSCOPY

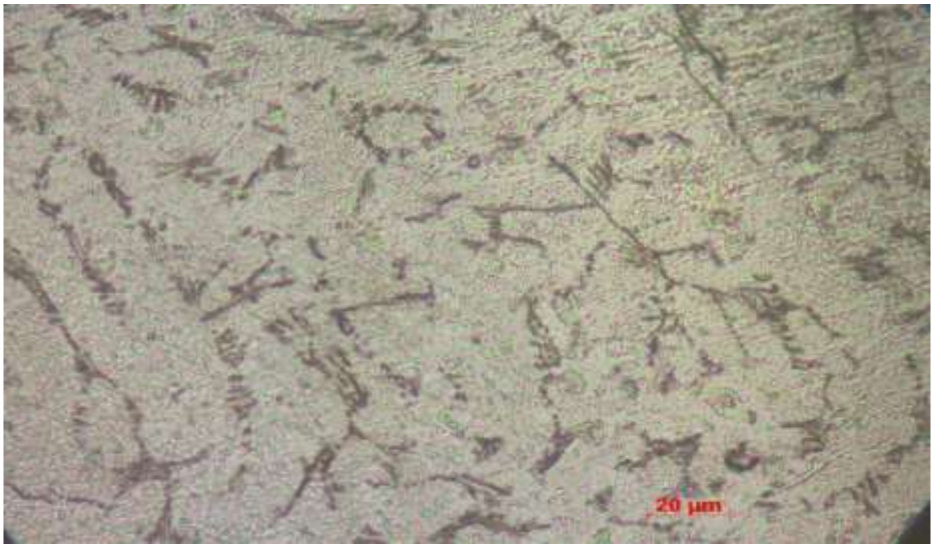

Fig. 5. Optical micrograph of the AE42 alloy (Magnification: 500x)

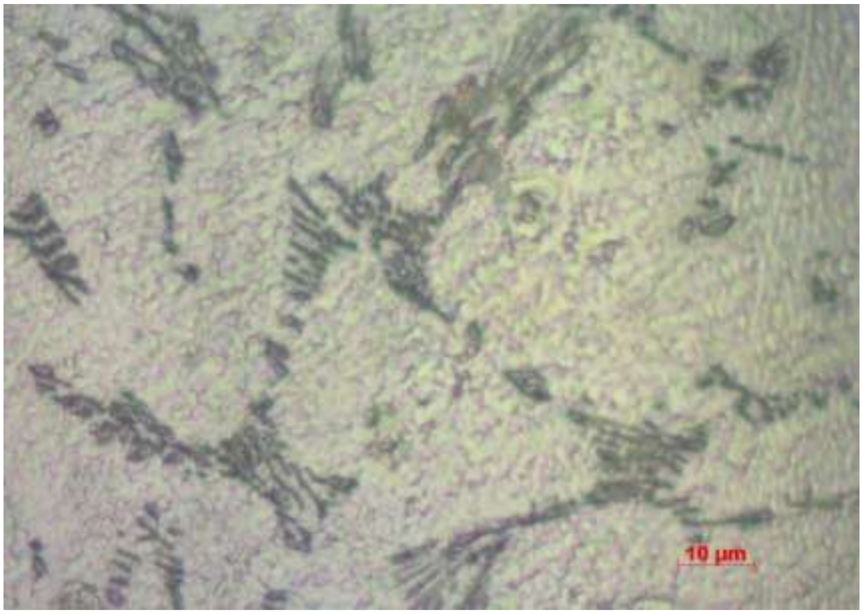

Fig. 6. Optical micrograph of the AE42 alloy (Magnification: 1000x)

SCANNING ELECTRON MICROSCOPY

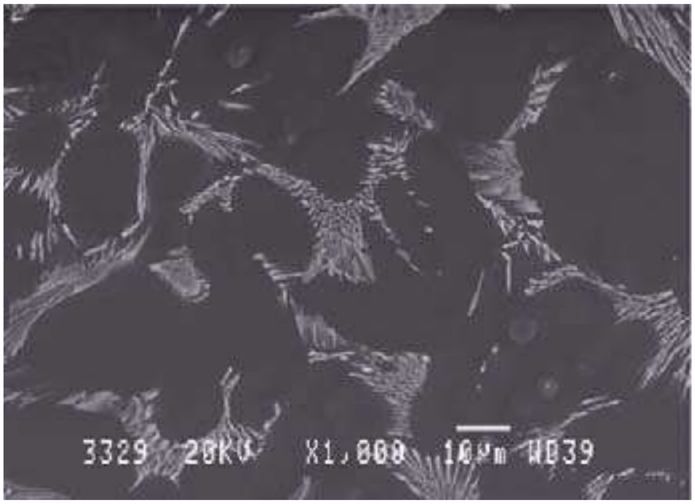

Fig. 7. SEM micrograph of the AE42 alloy

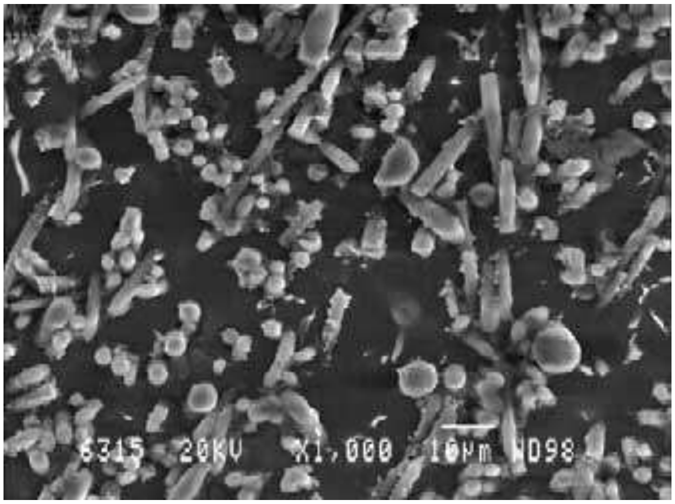

Fig. 8. SEM micrograph of the AE42 + 20% Saffil composite

On the above figure from SEM fig and fig shows that the microstructure of unreinforced alloy and the composite surface that is normal to the applied load ,hear the micrograph shows polygonal grains of the primary magnesium . hear the size of grain varies in a range of 25-35µm. And we cal also observed lamellar eutectic at the grain boundaries.

Microstructure of the composite they exhibits uniform distribution of fiber in the magnesium alloy matrix where there is no sign of any cluster formation found, microstructure is reasonably homogeneous having negligible variation of the local fiber volume fractions . no evidence of the residual macroporosity and bonding between the fiber and the matrix is good

The scanning electron microscopy images of both the unreinforced alloy and composite surface revealed grooves they are continuous and long **.**

X-RAY DIFRACTION AND PHASSE ANALYSIS

The x-ray diffraction pattern obtained from the AE42 alloy is shown below.

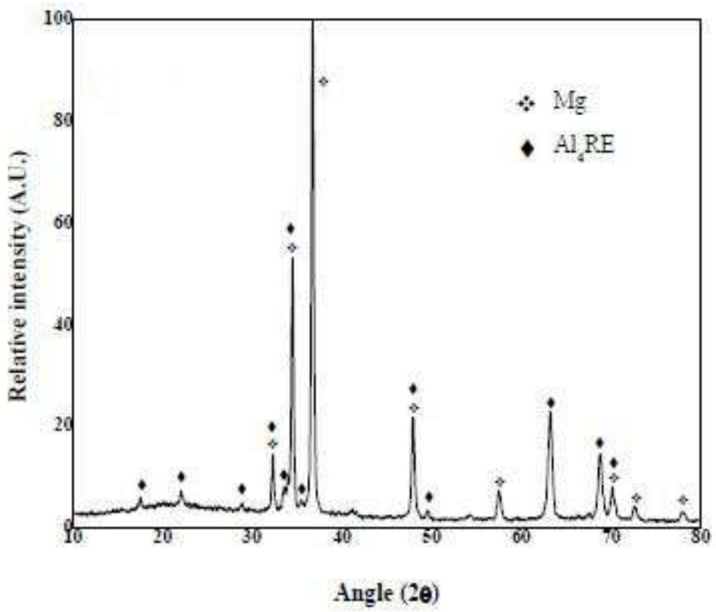

Fig -9 XRD pattern obtained from the AE42 alloy

The pattern shows α-Mg peaks along with the peaks corresponding to Al_4RE phase present in the graph. Here the phase Al_4RE is considered to be similar to other phase like $Al_{11}RE_3$ and it is denotated as Al_4RE .

Along the triple point and the grain boundary the bright contrast phase is observed which is Al_4RE phase.

In case of the composite α-Mg, Al_4RE and Al_2O_3 were present.

HARDNESS TESTING AND VALUES

Fig. 10. INDENTATION ON AE42

Fig -11. INDENTATION ON AE42 + 20% SAFFIL

OBSERVATION

table no. 4 **hardness data for AE42**

sl. no.	HV	mean HV
01	44.6 HV	
02	42.5 HV	
03	43 HV	43.325HV
04	43.2HV	

Table no. 5

AE42 + 20% Saffil

Sl. No.	HV	Mean HV
01	59.5 HV	
02	52.1HV	
03	54.7HV	55.4HV
04	55.3HV	

*LOAD APPLIED IS 5KG

The hardness of the AE42 and the composite were measured in a Vickers hardness testing machine with a applied load of 5 kg and 10sec is the dwell time. The Vickers hardness of the AE42 is found to be 43.325HV (average of four measurement) , the hardness is found to be lower than its composite AE42 + 20% saffil which Vickers hardness is found to be 55.4HV. So composite got hardness higher than its alloy AE42.

CONCLUSION

After observing and the present study and the result and their pertinent analyses lead to infer the following conclusions:

- In case of AE42 alloy, Primary Mg and Al_4RE were observed whereas in case of composite primary-Mg, Al_4RE and Al_2O_3were observed.

- The short fibers were uniformly distributed in the matrix of AE42 alloy.

- The hardness of the (AE42 + 20 % saffil) composite was observed to be higher than that of AE42 alloy.

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