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Fabrication and testing of aluminum metal matrix composites with Graphene and Yttrium oxide

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ABSTRACT

The paper describes about the fabrication of Aluminium-Magnesium-Graphene-Yttrium oxide particulate composites produced using casting method. The size of the Graphene and Yttrium Oxide particulate is ranging between 20-40 µm and 40-60 nm. The Graphene contents are varied from 2% and 4% by weight and Yttrium of 4% and are dispersed in the alloy matrix. After the casting process the mechanical properties are mainly been tested, particularly their tensile and hardness of composites is measured. The micro structure of the composite material is mainly determined using a Scanning Electron Microscope (SEM).

Keywords: *Al-Mg alloy, Reinforcement, Composites, Hardness, Ultimate Tensile Strength, Microstructure.*

1. INTRODUCTION

Aluminium metal matrix composites materials are mainly used for light weight structural application. The silicon carbide is mainly used as reinforcement in Al, Al-Mg alloy[1-3].Composites with Silicon Carbide as reinforcement in aluminium alloy are mainly produced by powder metallurgy processing and casting method[4-5]. It has mainly been identified that there is significant increase in stiffness, strength, and creep strength and wear resistance when compared with the unreinforced aluminium alloy. The composites can be produced by conventional metal working processes such as extrusion, forging, rolling. These composites are mainly used in the applications of aerospace structure, automobile engine components, etc.

Yttrium oxide (Y2O3) particulates are light weight metal matrix composites. Yttrium oxide has a specific gravity of 4.47g/cm^3 and Graphene has about 2.2g/cm^3 when compared with aluminium (2.7g/cm^3). It has a high thermal coefficient of expansion, higher strength & stiffness [6-7].In the present investigation; we have prepared Aluminium-Magnesium-Graphene-Yttrium oxide composites using casting process. The main objective is to fabricate and determine the microstructure and mechanical properties of the composites.

The Metal matrix Composites (MMCs) are emerging as important engineering materials in the field of aerospace, automotive industries. Aluminium or its alloy is mainly used as a material due to its low density, fabricable and easily available. The benefits of aluminium metal matrix composites over other materials mainly include increase in stiffness, improved wear resistance and high stability [8-9]. In this present work graphene and yttrium oxide was chosen as reinforcement because of its higher hardness and strength when compared to other materials.

2. EXPERIMENTAL PROCEDURE

2.1 Preparation of test specimens

Al-Mg alloy with particulate reinforcement of graphene and yttrium oxide composites were fabricated by casting process. In this Al-Mg alloy was first taken in furnace as per the required quantity and heated to around 600^{0}C. The melt was continuously supplied with argon gas, and it was stirred and monitored. Argon gas was mainly introduced in the furnace to reduce the oxidation of the melt. The alloy was heated for 600^{0}C for 1 h and the graphene and yttrium oxide was slowly added to the Al-Mg melt. The complete mixing of powder with the melt was monitored and done by uniform stirring. This ensures the dispersion of the particle uniformly into the melt. The process was initiated for about 15 min to obtain a homogeneous composite of alloy. The argon gas was continuously supplied throughout the process. The molten melt alloy was then poured into a graphite mold, which was preheated to

200^0C. Rod of 100mm height were machined and extruded in the form of rod from the composite material. Composites with different composition of graphene and yttrium oxide were fabricated. The Microstructure fabricated composite materials were mainly determined by means of SEM, EDAX.

The Tensile properties of the composite materials were detected by means of universal testing machine. The hardness properties of the material were by using a Vickers hardness testing machine.

2.2 Microstructure characterizations

In the microstructure studies, specimens were cut from the extruded rods, ground with grit paper, in the dimension ratio of 1:1. The mounted samples were then mechanically polished using a 4.0 grade sand paper. Fine polishing to near mirror like finish was achieved using acetone and alcohol. The morphology and the distribution of the particle into the composite were identified by examining the samples in a VEGA III TESCAN make Scanning Electron Microscope (SEM).

2.3 Mechanical testing

Tensile tests were performed using a Universal testing machine to determine the tensile properties of the specimen. Each test result are described in this paper, mainly it indicate the strength and stiffness of the material being tested. The hardness properties measurements were performed using a standard Vickers hardness testing machine. It is the average obtained from at least three test specimens taken from the different location in the mould.

3. RESULTS AND DISCUSSION

3.1 Microstructure of cast composites

The microstructure of the composites material was determined by means of scanning electron microscope (SEM). The micrographs revealed a relatively uniform distribution of reinforced particles and good interfacial integrity between matrixes. The Microstructures of Al-Mg-Gr-Y2O3 composites containing in different composition are shown in Fig 3.1, 3.2 and 3.3 respectively. These photographs show that the graphene and yttrium are uniformly dispersed in the aluminium matrix.

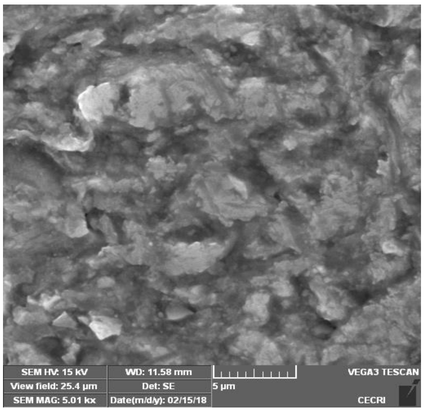


Fig 3.1 Microstructure of Al-Mg alloy

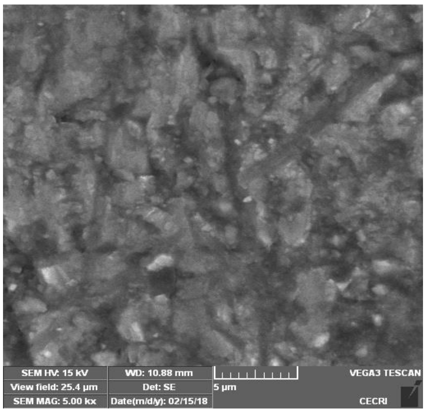


Fig 3.2 Microstructure of Al-Mg-Gr alloy

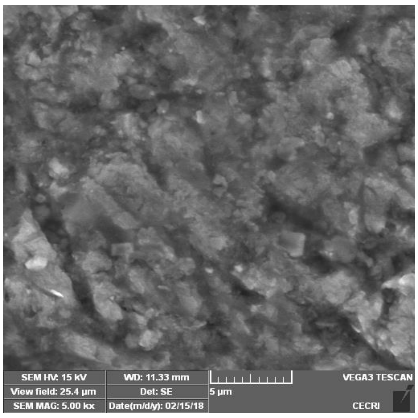
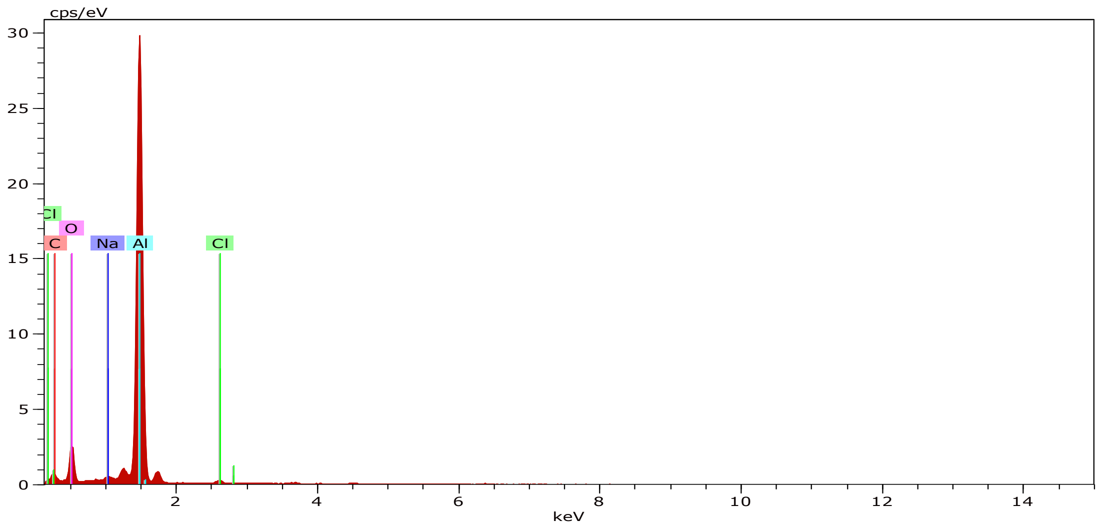


Fig 3.3 Microstructure of Al-Mg-Gr-Y2O3

3.2 Energy Dispersive Analysis of X-ray (EDAX)

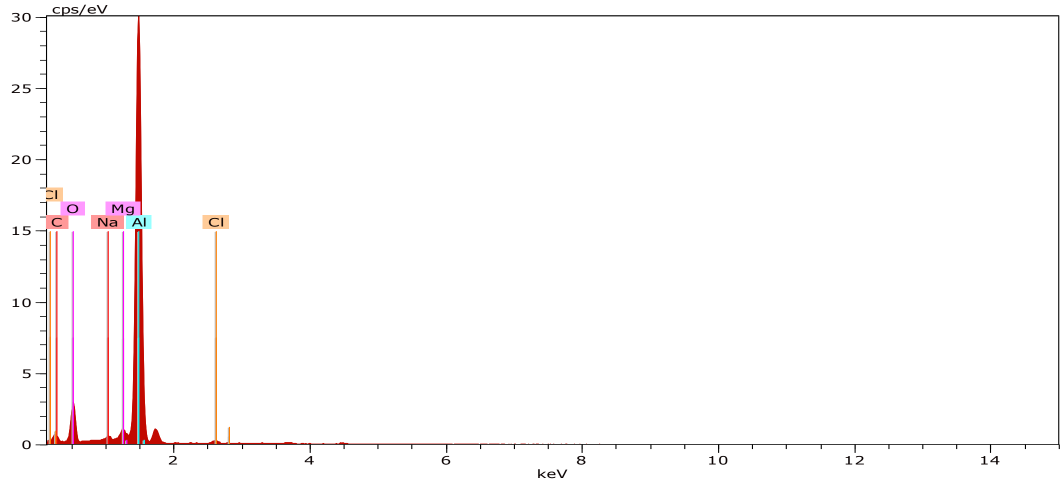
The elemental composition of Al-Mg alloy, Al-Mg-Gr alloy and Al-Mg-Gr-Y2O3 alloy was assessed by EDAX spectral analysis. The EDAX spectrum exhibits the presence of Al and Mg, Gr, Y2O3 in the material. The EDAX values are shown in below Fig 3.4, 3.5 and 3.6.



Spectrum: Acquisition 7324

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
Al	13	K-series	57.41	59.24	43.14	2.69	0.441	1.342	1.000	1.002
O	8	K-series	19.95	20.58	25.28	2.75	0.317	0.649	1.000	1.000
C	6	K-series	18.01	18.58	30.40	3.08	0.428	0.434	1.000	1.000
Na	11	K-series	0.96	0.99	0.85	0.09	0.009	1.063	1.000	1.015
Cl	17	K-series	0.58	0.60	0.33	0.05	0.003	1.785	1.000	1.007
		Total:	96.91	100.00	100.00					

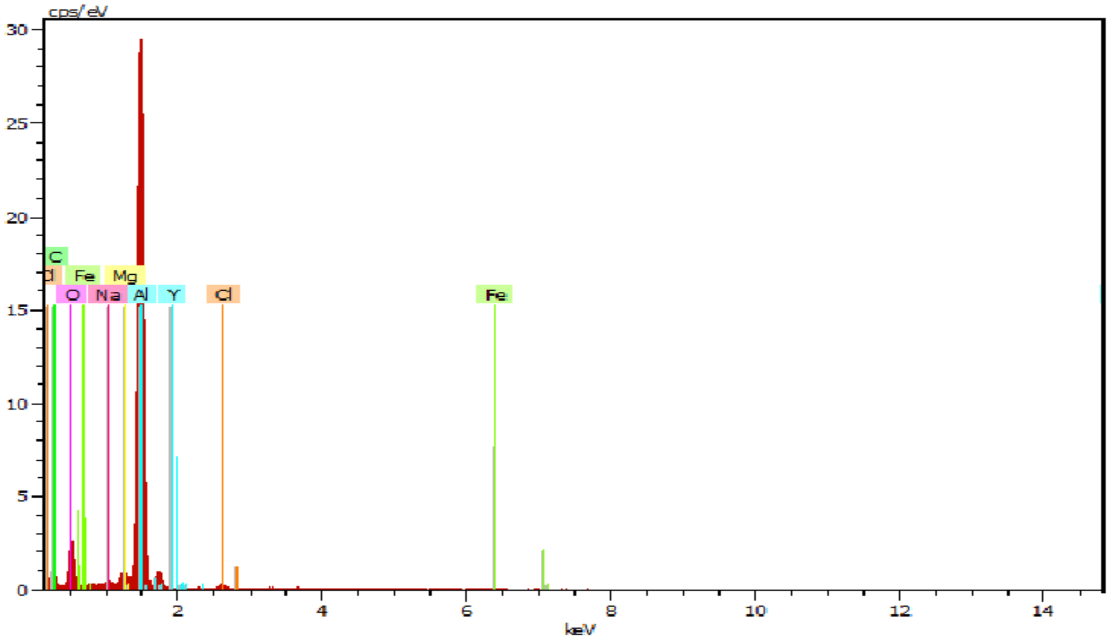
Fig 3.4 EDAX analysis of Al-Mg alloy



Spectrum: Acquisition 7325

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
Al	13	K-series	57.07	58.43	42.98	2.67	0.442	1.321	1.000	1.002
O	8	K-series	20.80	21.29	26.41	2.82	0.334	0.637	1.000	1.000
C	6	K-series	16.53	16.92	27.96	2.85	0.397	0.427	1.000	1.000
Mg	12	K-series	1.78	1.82	1.49	0.13	0.015	1.218	1.000	1.029
Na	11	K-series	0.97	0.99	0.86	0.09	0.009	1.047	1.000	1.015
Cl	17	K-series	0.53	0.55	0.31	0.05	0.003	1.756	1.000	1.007
		Total:	97.69	100.00	100.00					

Fig 3.5 EDAX analysis of Al-Mg-Gr



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Spectrum: Acquisition 7326

El AN  Series   unn. C norm. C Atom. C Error (1 Sigma) K fact. Z corr. A corr. F
corr.
                [wt.%]  [wt.%]  [at.%]           [wt.%]
--------------------------------------------------------------------------------
------
Al 13 K-series  61.33   55.26   39.57             2.87    0.462   1.193   1.000
1.002
C   6 K-series  23.73   21.38   34.39             3.85    0.564   0.379   1.000
1.000
O   8 K-series  21.39   19.27   23.27             2.95    0.337   0.572   1.000
1.000
Mg 12 K-series   1.85    1.66    1.32             0.13    0.015   1.101   1.000
1.027
Na 11 K-series   1.10    0.99    0.84             0.10    0.010   0.945   1.000
1.014
Cl 17 K-series   0.74    0.67    0.36             0.06    0.004   1.586   1.000
1.007
Fe 26 K-series   0.72    0.64    0.22             0.07    0.004   1.358   1.000
1.080
Y  39 L-series   0.14    0.12    0.03             0.04    0.001   0.826   1.000
1.003
--------------------------------------------------------------------------------
------
        Total: 110.99  100.00  100.00
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Fig 3.6 EDAX analysis of Al-Mg-Gr-Y2O3

3.4 Mechanical Properties

Table 3.1: Tensile properties and Micro hardness test of composites

SPECIMEN	UTS (KN)	% Elongation	Hardness (Vickers)
Al-Mg	14.34	19	84.45
Al-Mg-Gr	13.62	5.6	86.53
Al-Mg-Gr-Y2O3	17.36	12	91.40

From the above table it is clear that addition of Graphene and Yttrium oxide leads to improvement in the ultimate tensile strength of the alloy and increase in hardness value is more in case of Al-Mg-Gr-Y2O3 as compared with others. Thus from the table we can understand that with the addition of reinforcement there is a significant increase in hardness and strength of the material.

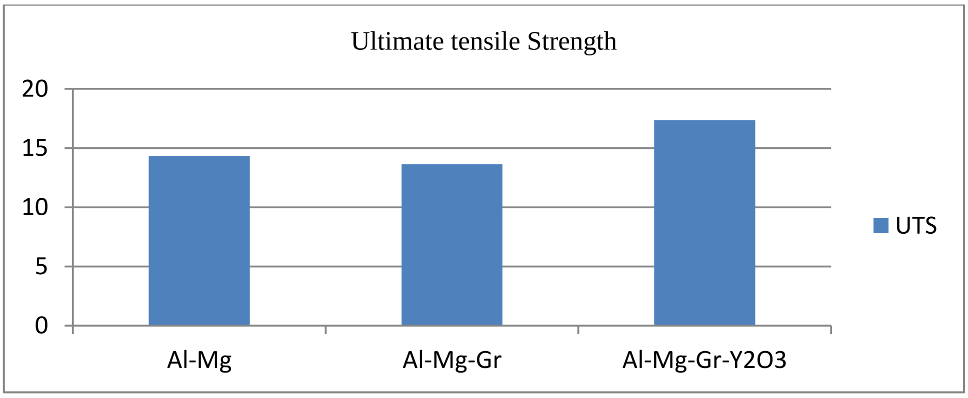

Fig 3.7 Ultimate tensile strength

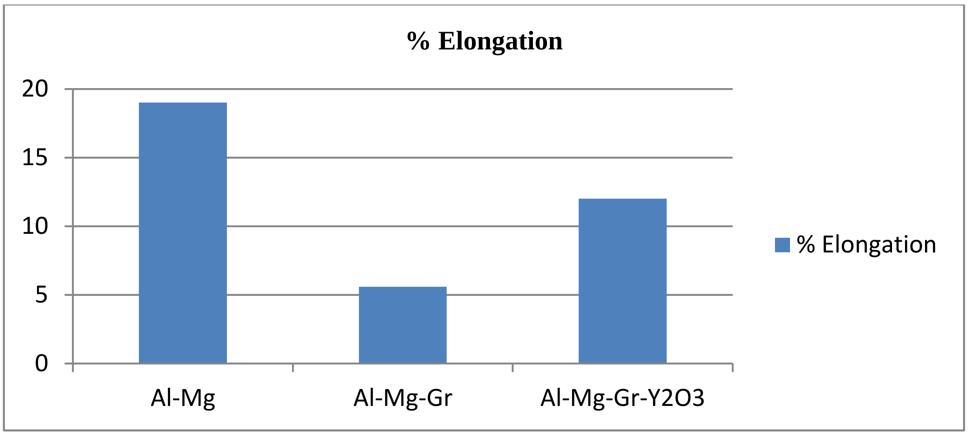

Fig 3.8 % Elongation

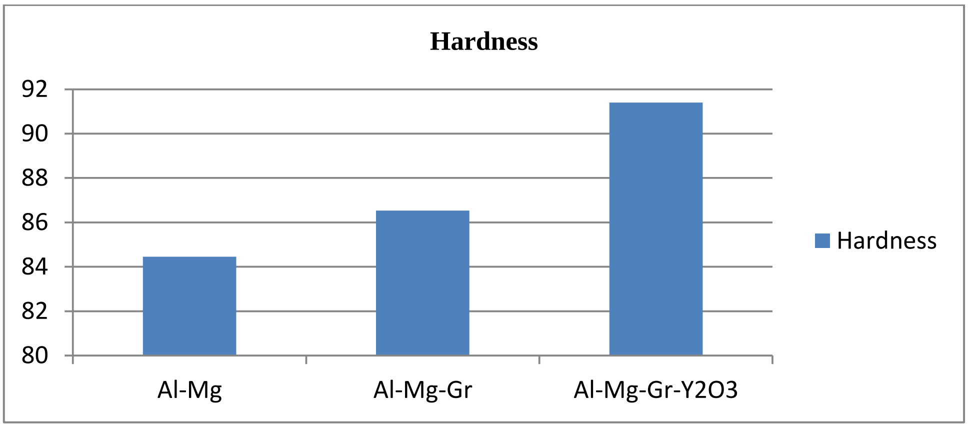

Fig 3.9 Hardness

4. CONCLUSION

The Optical micrographic study and SEM analysis revealed the presence of graphene and yttrium oxide particles in the composites with homogeneous dispersion. The Vicker's hardness of AMCs was found to be increased for the Al-Mg-Gr-Y2O3 sample of 8% when compared to the Al-mg sample. The tensile strength of AMCs was found to be increased for the Al-Mg-Gr-Y2O3 sample with 21% higher than that of the Al-Mg sample.

5. REFERENCES

[1] W. D. Callister, Jr., "Materials Science and Engineering", John Wiley & Sons, (2008), page 400-736.
[2] M. Kozma. "Friction and wear of aluminum matrix composites". National Tribology Conference. Galati, Romania (2003), page 99–106.
[3] M.A. Maleque, A. Atiqah, R.J. Talib, H. Zahurin, "Journal of Mechanical and Materials Engineering", (2012), page.166.
[4] Biswas PK, Dev SC, "Mg alloy and composites as the future challenging material for automobile applications". Ind Foundry J (1999; 45(3):17-26
[5] Perquleryuz MO, "Review cast Mg alloy for elevated temperature allpications". J Mater Sci (1994); page 59-71
[6] Lewandowski JJ.In:Clyne TW, "Metal matrix composites", vol.3. Amsterdam: Elsevier; (2000). P. 151-187
[7] Divecha Ap, Fishman SG, Karmakar SD. "Synthesis of metal-matrix composites". J Metals (1981);33:page 12-15
[8] Nair SV, Tien JK, Bates RC. Int metals Rev (1985);30(6):285-297
[9] R.W. Ruddle, "solidification of casting". J. inst met, 77(1950) page 37-39

