Journal of Engineering Research and Application www.ijera.com
ISSN : 2248-9622, PP 71-76

RESEARCH ARTICLE OPEN ACCESS

Characterization of Magnesium Based Flyash Reinforced Composite Using Powder Metallurgy

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ABSTRACT: *Magnesium based flyash (FA) reinforced composites were characterized using the powder metallurgy technique followed by sintering. Up to 0.5 to 2 wt. % of fly ash were added as reinforcements. The effects of FA on the mechanical properties of Mg were investigated. Mechanical property characterizations reveal an improvement of hardness with higher weight percentage of FA incorporated. An attempt is made to compare the values of pure base and the reinforcement material with mixed compact.*
Key Words*-Compaction, Density,Fly ash,Hardness,sintering,Magnesium,Powder metallurgy.*

I. INTRODUCTION

A material in which one or more phases are distributed in a solid metal or alloy matrix can be regarded as Metal matrix composite (MMC). The need for light weight, high strength materials has been recognized since the invention of the airplane. The inadequacy of metals and alloys in providing both strength and stiffness to structure has led to the development of metal matrix composites. Among the various types of MMCs, light-weight MMCs

such as magnesium (Mg) based composites are arousing more interest due to their potential applications in aerospace, automotive and sportsequipment industries. Magnesium based composites are known to have high specific mechanical properties , low density, improved thermal and dimensional stability and better damping properties. From previous studies,

it was found that metal based composites reinforced with nano-size particulates can yield better properties than those reinforced with micron-size reinforcements. Magnesium (Mg) and its alloys are gaining more recognition as a lightest structural material for lightweight applications, due to their low density and high stiffness-to-weight ratio.Fly ash is finely divided mineral residue resulting from the combustion of ground or powdered coal in thermal power plants. It possesses low density, Inexpensive, abundantly available hence, it is an excellent candidate reinforcement material for Metal matrix composites. An addition of fly ash particles reduces the cost and density of matrix.Thus, they differ from traditional composites where the constituents are at the macroscopic (micrometer to millimeter) level.

The objective of this investigation involves in fabrication of flyash reinforced magnesium composite by powder metallurgy technique whichinvolves Blending of reinforcement and magnesium powders, Compaction of these blended samples to form a billet , Compacted billets are then sintered at a temperature less than the melting point of the base metal i.e., matrix material, Finally the sintered billets are characterized for mechanical properties under different conditions.

Fly ash is finely divided mineral residue resulting from the combustion of ground or powdered coal in thermal power plants. It primarily comprises of SiO_2 (65%), Al_2O_3 (24%) and Fe_20_3 (5%), with a mean particle size of less than 60 microns. It possesses low density (210 gm/cc), Inexpensive, abundantly available hence, it is an excellent candidate reinforcement material for Metal matrix composites. Additions of fly ash particles reduce the cost and density of matrix. After recognizing the immense potential of fly ash it can be used as reinforcements.

II. LITERATURE REVIEW

Ravi Shankar[1]et.al.were worked on the Effect of Fly Ash Particles on the Mechanical Properties and Microstructure on Compacted Magnesium Reinforced With SiC Particles. It shows that Composites samples with fly ash can be used to reduce the cost of the metal matrix for applications in automotive and small engine applications and it was achieved by reinforcing the Mg-composites with a high strength component. The experiment mainly concentrated on the evaluation of thermal behavior of Mg-composites reinforced with SiC in addition with variation of fly ash. Magnesium reinforced with SiC particles were prepared by powder metallurgy technique and the micro structural analysis and micro hardness test were carried out to see the behavior of material properties towards heating and cooling. The micro hardness of composite increased by 30 % than that of aluminium composite. Wear rate shows a greater improvement of 10% wear resistance than that of aluminium composite.

From the experiments carried out by the authors have been derived that, the specimen with 20 % fly ash Content were found to be more stableunder compressive loading and higher temperature with various percentages of fly ash reinforcement compared to Mg / SiC specimen tested. The Optical images revealed that both SiC and fly ash particles are well distributed in Magnesium Matrix. With the addition of fly ash with higher percentage the rate of heat transfer from specimens decreases as revealed by temperature time plot for heating and cooling. Increase in area fraction of reinforcement in matrix result in improved hardness values. A decrease in hardness of each specimen was found after thermal cycling. Addition of fly ash particles up to 10 % resulted in an increase in micro hardness of specimens. With the addition of fly ash to Mg-SiC the wear resistance of the composite decreased which is due to the clusters of SiC particles in the specimen. It is very cleared from the results that the specimen with highest percentage of fly ash worn out more rapidly as compared to the other specimens during wear test.

P Shanmugasundaram and R Subramanian[2]has given in their paper the influence of magnesium and stirrer model in production of aluminium fly ash composites by Taguchi approach. The aluminium and fly ash composites were produced by stir casting process and achieved the homogeneous distribution of reinforcements within the matrix. Optimum parameters were identified for attaining the maximum mechanical properties by the application of Taguchi method and the obtained results were validated by confirmation test. The results of the paper suggest that the addition of fly ash content with matrix increases the tensile strength and the hardness compared to the base matrix.

Sankar.L[3]et.al. In their paper Comparison study of al-fly ash composites in automobile clutch plates they discussed about materials widely used in engineering field. The composite materials has good characteristic of resisting wear resistance, hardness and tensile strength. Due to less weight and good strength the composite materials plays a vital role in engineering field. Aluminium LM6 has been used as matrix material and various weight percentage of fly ash (5%,10%,15%). The mechanical behaviour and microstructure of Al-Flyash composites are investigated. Mg is added to reduces the surface tension and avoids the rejection of the particles from the melts. In this paper we have suggesting fly ash composite material in automobile clutch plate and reducing the wear resistance.

The literature survey reveals that there is no clear information on the role of size, distribution and the amount of fly ash reinforcement with pure magnesium to achieve the good mechanical properties. In addition there is no clear literature exists on the influence of flyash using powdermetallurgy to achieve the properties with results. There fore the present investigation is taken up to throw a light on the effect of composite with light weight materials and reinforcement with individually very good properties and to identify the microstructure of mixture and various mechanical properties involving Hardness, compaction, tensile, studies at various amount of materials under different conditions.

III. METHODOLOGY

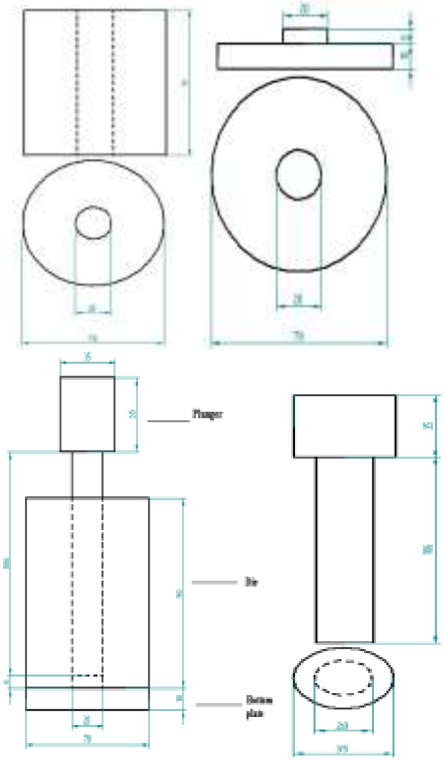
A. **Selection of Material** :

Magnesium powder of purity more than 99.6% was used as the matrix material of 40 micron size supplied by Libra Magnesium Products shown in fig.1a and & reinforcement material Fly ash was collected from Polyfibres, Harihara shown in fig.1b.


Fig.1a. Magnesium Fig.1b.Flyash

B. Processing and compaction:

The powder metallurgy technique was used to get green compact of the composite using suitable compact die assembly under universal testing machine. The die should be prepared with steel material as per the design drawing shownin fig.2 and fig.3.



All dimensions are in mm

Fig. 2: Part drawing of compaction die

The base material and reinforcements with wt % of 0.5%, 1%, 1.5% and 2% with a interval of 0.5% Fly ash were added in pure magnesium powder using ball mill. The Mg powder was homogeneously mixed with the respective weight percentages was compacted in the die assembly using a 40 Ton capacity Universal testing machine shownin Fig.4 and the billets produced shown in Fig.5 by powder metallurgy are than sintered using vacuum furnace sintering shown in Fig.6 at a temperature of about 450^{0} C and than the testing will be done.

Fig.3 Disassembled & assembled parts of compaction die.

Fig.4 Die under UTM

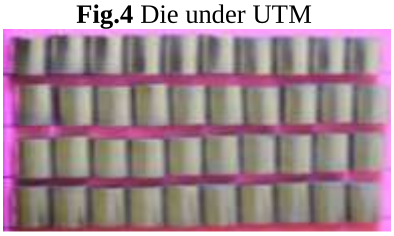


Fig.5 Compacted billets using die under UTM

Fig.6 Vacuum Furnace Sintering

IV. EXPERIMENTATION RESULTS AND DISCUSSIONS

C. Density

The mass density of a material is its mass per unit volume and specific weight is defined as its weight per unit volume. The density of a material varies with temperature and pressure. Increasing the pressure on an object decreased the volume of the object and thus increases its density. Increasing the temperature of a substance decreases its density by increasing its volume.

TABLE I.DENSITY CHART FOR VARIOUS COMPOSITION BEFORE SINTERING AND AFTER SINTERING OF MG/FA SPECIMEN

Composition	Before Sintering In gm/Cm^3	After Sintering In gm/Cm^3
Mg-0.5% FA	1.493	1.470
Mg-1% FA	1.640	1.591
Mg-1.5% FA	1.632	1.485
Mg-2% FA	1.596	1.554

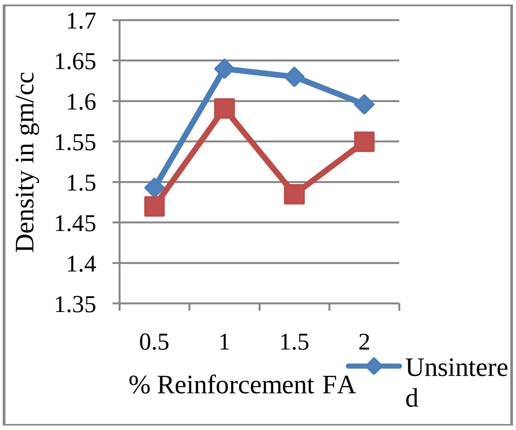


FIG.7 DENSITY TREND OF MG/FA BEFORE AND AFTER SINTERING

Fig.7 shows the trend plotted density against percentage of reinforcement in the matrix as per the values in Table I and the trend clearly indicates the density of composites will decrease as the reinforcement increases and the values of specimens before sintering are higher than that of sintered specimens.

D. Hardness

Hardness of the specimens of Magnesium and Flyash reinforced composites were determined by using Rockwell Hardness Testing apparatus as per ASTM B-925.Fig.8 shows the specimen under Rockwell hardness tester and the tested specimens for various compositions were shown in fig.9 The results are tabulated in Table II It is investigated that Magnesium MMC composites, the hardness increases with the addition of Flyash up to 2 wt %.

Fig.8 Sample for RHN test

Fig.9 Samples of Mg/FA after RHN test

TABLE II. HARDNESS VALUE OF MG/FA SPECIMENS BEFORE AND AFTER SINTERING

Reinforcement	Rockwell Hardness number	
	Before sintering Average value	After sintering Average value
Mg-0.5% FA	16.6	17.8
Mg-1% FA	16.65	19.7
Mg-1.5% FA	17.5	24.93
Mg-2% FA	25.53	31.66

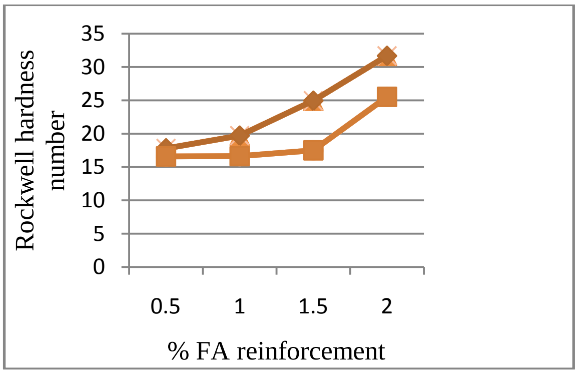


FIG.10 HARDNESS TREND OF FA/MG BEFORE AND AFTER SINTERING

The Fig.10 shows the trend of comparison of hardness of matrix FA reinforced composites before and after sintering values as shown in Table II. The sintered composites found to be harder than the unsintered composites. Due to higher hardness of dispersion particles there in percentage of hardness increases with increase in percentage of FA.

E. Compressive strength

A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, squashed, crushed. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to break. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test. The tests were conducted on the specimens placing between the fixtures of Universal testing machine shown in Fig.11a and the compression load is applied shown in Fig.11b.

Fig.11a.Sample under UTM before load

Fig.11 b. afterload

TABLE III.COMPRESSION VALUES OF MG/FA COMPOSITES BEFOR AND AFTER SINTERING

Composition	After Sintering		Before Sintering	
	Load (KN)	Displacement (mm)	Load (KN)	Displacement (mm)
Mg-0.5%FA	12.86	2.4	10.86	3.6
Mg-1%FA	16.7	1.2	14	5.4
Mg-1.5%FA	21.34	2	18.12	6.5
Mg-2%FA	27	2.5	21.7	4

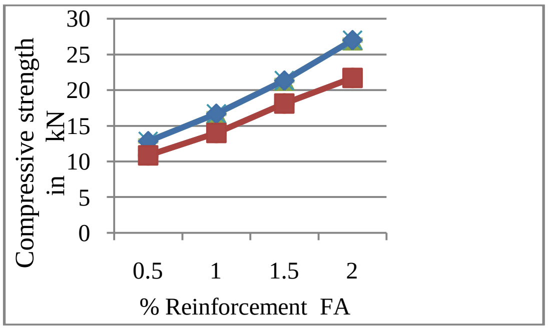


FIG.12 GRAPH FOR WT.% OF MG/FA V/S COMPRESSIVE STRENGTH FOR COMPOSITES BEFORE AND AFTER SINTERING

The Fig.12 shows the graph plotted for compressive strength against different percentage of reinforcement for sintered and unsintered specimens as per the value of Table III and it clearly indicates the compressive strength of sintered specimens will increase as the percentage of reinforcement increases as compared to unsintered specimens and also the table clearly indicates the values of displacement with respect to increase of percentage and loads the sintered specimens are showing better results than unsintered specimens.

F. Tensile strength

Tensile tests were generally carried out on a universal testing machine but in this study Tensometer is used to conduct tensile test as the specimens were of subsize and unmachined flat as per the ASTM E8 standards. The test samples were prepared as per the ASTM E8 standard as shown in Fig.13 using die prepared for powder metallurgy technique. Under static loading conditions the test was conducted for yield strength & tensile strength along with the elongation of the specimen under load in tensometer shown in Fig.14

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Fig.13 Standard flat Unmachined tension test specimen die as per ASTM & Specimens

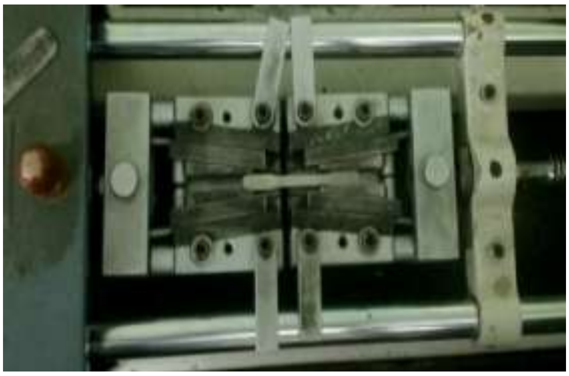

Fig.14 Tensile specimen in TENSOMETER for test

TABLE IV.TENSILE PROPERTIES OF MG/FA COMPOSITES

Composition	Yield Strength (N/mm^2)		Ultimate Tensile Strength (N/mm^2)		Elongation %	
	Unsintered	Sintered	Unsintered	Sintered	Unsintered	Sintered
Mg+0%FA	1.85	1.346	1.075	1.531	1.72	1.12
Mg+0.5%FA	1.774	2.309	2.668	3.037	0.80	0.75
Mg+1%FA	1.880	2.087	2.092	2.451	1.20	0.80
Mg+1.5%FA	1.348	3.176	2.192	3.848	1.44	1.28
Mg+2%FA	1.108	2.263	2.187	2.615	1.24	1.04

From the Table.IV it has been the observed that Tensile strength increases remarkably with an increase in weight percentage of FA in the composites. It is also observed that Yield strength increases remarkably with an increase in weight percentage of FA in the sintered composites compared to unsintered composites.

V. CONCLUSIONS

Magnesium powder as matrix mixed with Flyash(FA) in weight percentages of 0, 0.5, 1, 1.5 , and 2%(wt) as reinforcement were produced through powder metallurgy route. The specimens were Sintered and tests were conducted successfully. Specimens were subjected to evaluate the behavior of mechanical properties of MMC's. From the investigation, following points areconcluded.

- ➢ Hardness of Mg/FA composite is greater than pure Mg and

better after sintering.

- ➢ Compressive strength increases with increase in percentage

of reinforcement and sintered specimens gives better results than unsintered.

- Yield strength increases remarkably with the increase in

Reinforced particulate for sintered specimens.

- Tensile strength increases with the addition of FA for

sintered specimens compared to unsintered specimens.

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