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Evaluation of the Mechanical Properties on Aluminium Alloy 2024 -Fly Ash Metal Matrix Composite

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Abstract

Aluminium alloys are widely used application due to their low density, good mechanical properties, better corrosion resistance, wear resistance, low thermal coefficient of expansion as compared to conventional metals and alloys. Fly ash is chosen because of it is least expensive and low density reinforcement available in large quantities as solid waste by-product during manufacturing of bricks. Due to low weight it can be utilized in automobile and thus improving its life. The present work has been done on Al alloy 2024-Fly ash composite. These were fabricated using aluminium 2024 alloy as metal matrix and fly ash as reinforcing material. Various weight based composites like (Al 98% - FA 2%), (Al 96% - FA 4%), (Al 94% - FA 6%), (Al 92% - FA 8%),(Al 90% - FA 10%) were fabricated by powder metallurgy technique. The obtained composites were sized into small specimens and tests like hardness test, wear test, density test and corrosion test were conducted on the samples, the obtained results were compared.

Keywords: Wear rate, powder metallurgy, sintering, mechanical properties, Hardness

INTRODUCTION

The most commonly used methods for manufacturing of MMCs are casting and powder metallurgy techniques. Powder metallurgy is a highly evolved method of producing reliable net shaped components by blending elements or pre alloyed powders together, compacting this blend in die and sintering in a controlled furnace atmosphere to bind particles. The present work deals with the fabrication of Al2024-FA particulate composite through powder metallurgy technique. Composites with

varying percentages of reinforcements i.e. 2, 4, 6, 8 and 10% based on weight were considered. The powders of Aluminium and Fly ash were mixed in a ceramic mortar with pestle uniformly. The blend was compressed in dies on universal testing machine at a pressure of 350Mpa to get the samples of size 12 mm diameters. These samples were sintered at elevated temperature of 440°C in muffle furnace for 1 hour and the samples were allowed to cool in the furnace itself for 72 hours. Hardness, wear, density and corrosion tests were conducted on the specimens and the obtained results of various composites were compared.

Govinda rajan.B has been investigated The aluminium is a matrix material and the reinforcements are E-glass fiber and fly ash with various weight fraction the E-glass fiber is constant and the fly ash is varied 0,3,6,9 wt. % fabricate by using stir casting method. The test result the tensile strength of the four different wt.% composite sample is increased gradually adding with increasing the fly ash wt.% gradually (0,3,6,9 wt.%), the 9 wt.% fly ash sample is get higher tensile strength 199.698 N/mm2 compared with other samples[1]Aluminium alloy A356.2 matrix and reinforcement of rice husk ash and Silicon carbide added at equal ratio of 2,4,6,8 wt.% is fabricated by double stir casting process. While increasing of reinforcements wt.% the porosity, hardness, yield strength and ultimate strength was increased in the composite and the density is decreased[2]. Aluminium alloy (Al-Mg-Si), RHA and Alumina (Al2O3) reinforcement at used with various combinations to fabricate the composite such as 0:10, 2:8, 3:7, 4:6 wt.% by using double stir casting method. In this composite was investigated as showed percentage elongation and fracture toughness was increased of the 2:8 wt.% sample and it containing low hardness, ultimate tensile strength and yield strength while increasing the reinforcements. So that the single alumina reinforcement only got higher than others samples[3]. aluminium alloy (Al-Si-10Mg) and Rice Husk Ash reinforcement in ratio of 3,6,9,12 wt. % using stir casting method fabricate the composite material. The tensile strength, compression strength and hardness was increased and the ductility gets decreased with increase in RHA weight fraction reinforcements[4]

Anil investigated the mechanical properties like compressive strength, ductility, and hardness by using aluminium fly ash composites. By increasing the weight fraction of the fly ash particles the above mentioned properties gets improved. Different composition needed to be added in the fly ash composites to enhance their properties further.

Vivekanandam have fabricated the aluminium fly ash composite by stir casting process. The addition of fly ash acts as a barrier to the movement of dislocations and there by increases the hardness of the composite. And also by adding fly ash to the aluminium in molten state increases the abrasive wear resistance. This strengthening of the composite is because of the solid solution strengthening, dispersion strengthening and particle reinforcement.

Garg have prepared a composite by using aluminium 6061 as the matrix and SiC, fly ash as the matrix material. The composite is produced by stir casting technique in which the weight fraction of the silicon carbide is varied (from 2.5%, 5%, 7.5%. 10%) by fixing the fly ash weight fraction (5%). From the analysis it is clear that by

increasing the weight fraction of SiC the tensile strength and hardness of the composite gets improved.

Prasad have investigated the mechanical properties of hardness and wear rate by using different casting techniques .In this, al –fly ash with 7.5% weight fraction has high hardness and wear rate when compared to the aluminium alloy produced by squeeze casting and gravity casting. And also the sample produced in this gravity casting has low hardness and high wear rate.

Arunkumar have chosen al6061 alloy as the matrix material and 2 to 8wt% of fly ash with 2 and 6wt% of e-glass fibre as the reinforcement to produce the composite by stir casting. The hardness, tensile strength and compressive strength increases as the wt % of fly ash increases. And also the samples were tested using ultrasonic flow detector to identify the defects.

Umashankar have opted Al6061 alloy as the matrix and bottom ash as the reinforcement to produce the composite by stir casting. Micro hardness and tensile strength of the composite increases with increase in wt% of bottom ash particles. But the problem is, after 9% wt of bottom ash the tensile strength and micro hardness decreases.

Sreenivasareddy have opted Al 7075 alloy as the matrix material and e-glass fibre with fly ash by varying the weight percentage to produce the composite .The hardness and tensile strength of the heat treated specimen is higher when compared to the cast specimen. The percentage of e-glass fibre and fly ash can be varied to enhance the mechanical properties further.

Shanmughasundaram revealed that by adding fly ash particles the compressive strength gets improved. Compressive Strength of the composites tends to drop when the fly ash content is raised from 20 % to 25 wt%. But beyond20 wt%, the fly ash particles interact with each other due to clustering of particles which reduces the strength.

Mahendra Boopathi mentioned a increase in hardness was observed with increase in weight fraction of SiC & fly ash. Maximum hardness is observed at Al/ (10%SiC+10%fly ash). Incorporation of fly ash particles improves the hardness and also the deformation of the Al matrix. It is observed that the fact that the combination of SiC with fly ash particles possess higher hardness than the aluminium alloy.

Uthayakumar have used aluminium alloy 6351 as the matrix material and fly ash with weight percentage (5 to 15%) as the reinforcement to produce the composite by stir casting. From the result it is clear that the composite does not wear at low loads. And the result shows that the applied load has the greatest effect on dry sliding wear.

Shivaprasad have used the aluminium alloy AA2024 as the matrix material and fly ash asthe reinforcement with 10% weight fraction, the composite is produced by stir casting. The hat treated AA2024+10% fly ash composite has improved were characteristics when compared to non-hate treated ones. The specific wear rate for water cooled condition is low when compared to air cooled condition.

Arun investigated the characteristics of aluminium –fly ash – alumina composite with

the stir casting process .Al 6061 is chosen as the matrix material and fly ash as the reinforcement. The reinforcement particulates are equally distributed in Al6061 alloys which is shown in SEM analyses.

FABRICATION METHOD

Fabrication methods are an important part of the design process for all structural materials, including MMCs. Considerable work is under way in this critical area. Significant improvements in existing processes and development of new ones appear likely.

Current methods can be divided into two major categories, primary and secondary. Primary fabrication methods are used to create the MMC from its constituents. The resulting material may be in a form that is close to the desired final configuration, or it may require considerable additional processing, called secondary fabrication, such as forming, rolling, metallurgical bonding, and machining. The processes used depend on the type of reinforcement and matrix.

POWDER METALLURGY

PRINCIPLES OF POWDER METALLURGY PROCESS:

Powder metallurgy is the process of blending fine powdered materials, compacting the same into a desired shape or form inside a mould followed by heating of the compacted powder in a controlled atmosphere, referred to as sintering to facilitate the formation of bonding of the powder particles to form the final part. (1) Blending of powders (2) Compacting of powders in a mould or die and (3) Sintering. Compacting is generally performed at room temperature and at high pressure. Sintering is usually done at elevated temperature and at atmospheric pressure.

Fig 1.0 Specimens in furnace

APPLICATIONS:

The applications of P/M are quite extensive. Metal powders are being used in the fabrication of tungsten lamp filament, dental restoration, oil-less bearing, automotive transmission gears, armour piercing projectiles, electrical contacts, nuclear power fuel elements, orthopedic implants, business ,machines, high temperature filters, aircraft brake pads, rechargeable batteries, and jet engine components.

RESULTS & DISCUSSIONS

Table 1.1 Hardness value of composites

S.No.	Composition by weight percentage	Rockwell Hardness Number
1	Al 100% - FA 0%	75
2	Al 98% - FA 2%	77.23
3	Al 96% - FA 4%	79
4	Al 94% - FA 6%	84.5
5	Al 92% - FA 8%	89.33
6	Al 90% - FA 10%	93

Hardness behavior of various composites**:**

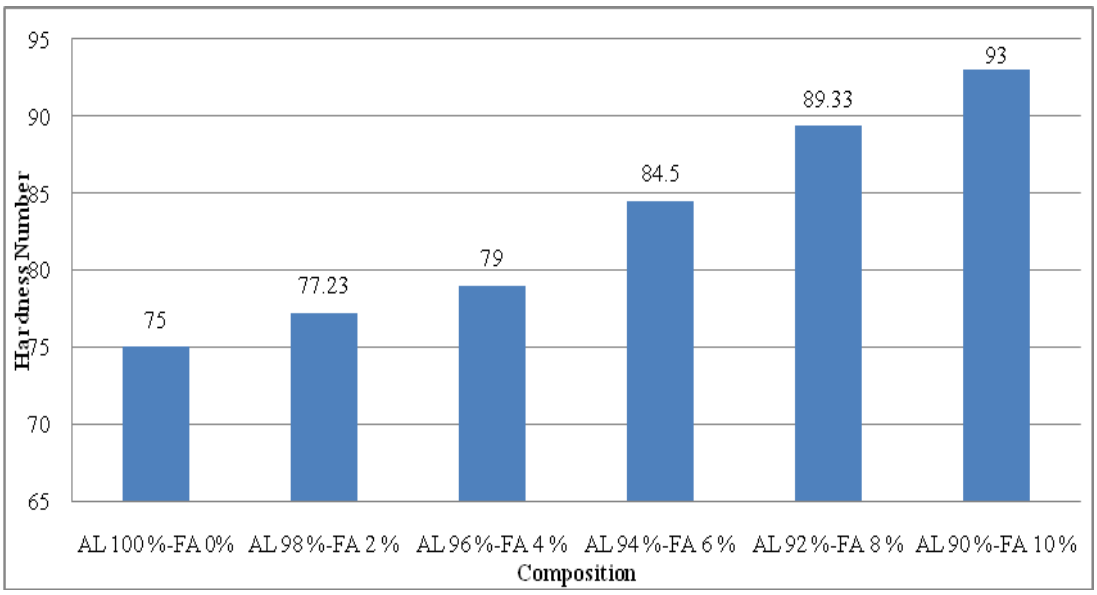

Fig1.1 Graphical representations of hardness values

It was observed that the hardness values were increased with increase in composition of Fly ash in Aluminium-Fly ash composite. Initially the hardness of Al2024 is 75 and it was increased to 93 on increasing the fly ash percentage.

Table 1.2 Wear rate of composites

S.No.	Composition by weight percentage	Material lost under the application of load in grams		
		10N	20N	30N
1	Al 98%-FA 2%	0.006	0.009	0.011
2	Al 96%-FA 4%	0.005	0.008	0.009
3	Al 94%-FA 6%	0.004	0.007	0.008
4	Al 92%-FA 8%	0.002	0.005	0.006
5	Al 90%-FA 10%	0.001	0.003	0.004

For the composites AL98%-FA2% the wear and friction behaviour are obtained as

Fig 1.3 Friction vs Distance for 10N load

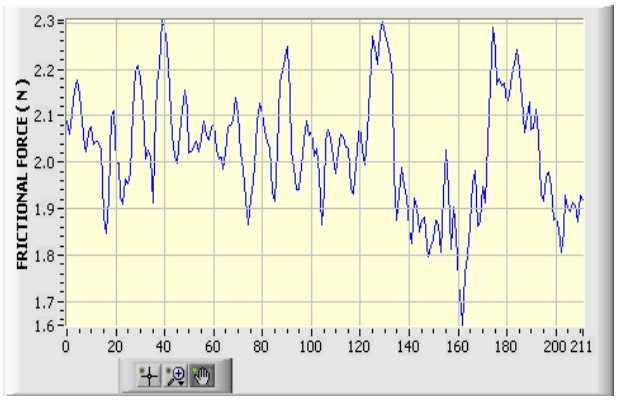

Fig1.2 Wear vs Distance for 10N

Fig 1.4 Wear vs Distance for 20N load

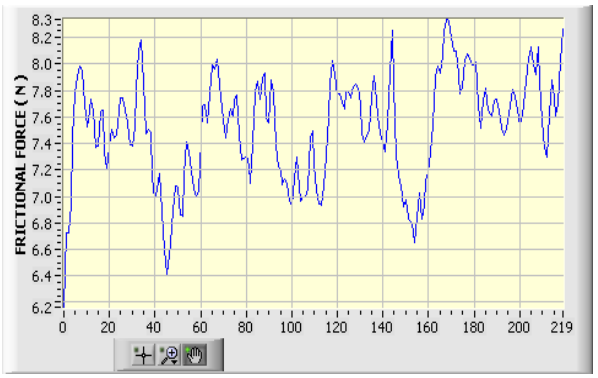

Fig1.5 Friction vs Distance for 20N load

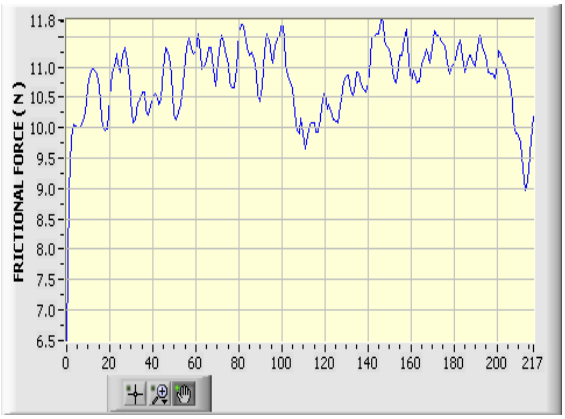

Fig 1.6 Wear vs Distance for 30N load **Fig 1.7** Friction vs Distance for 30Nload

Figures shows the material lost at different loads with varying distance. Similar graphs have generated at different compositions From that, the values has been taken of wear rate &frictional force at different compositions.

Wear behavior of various composites:

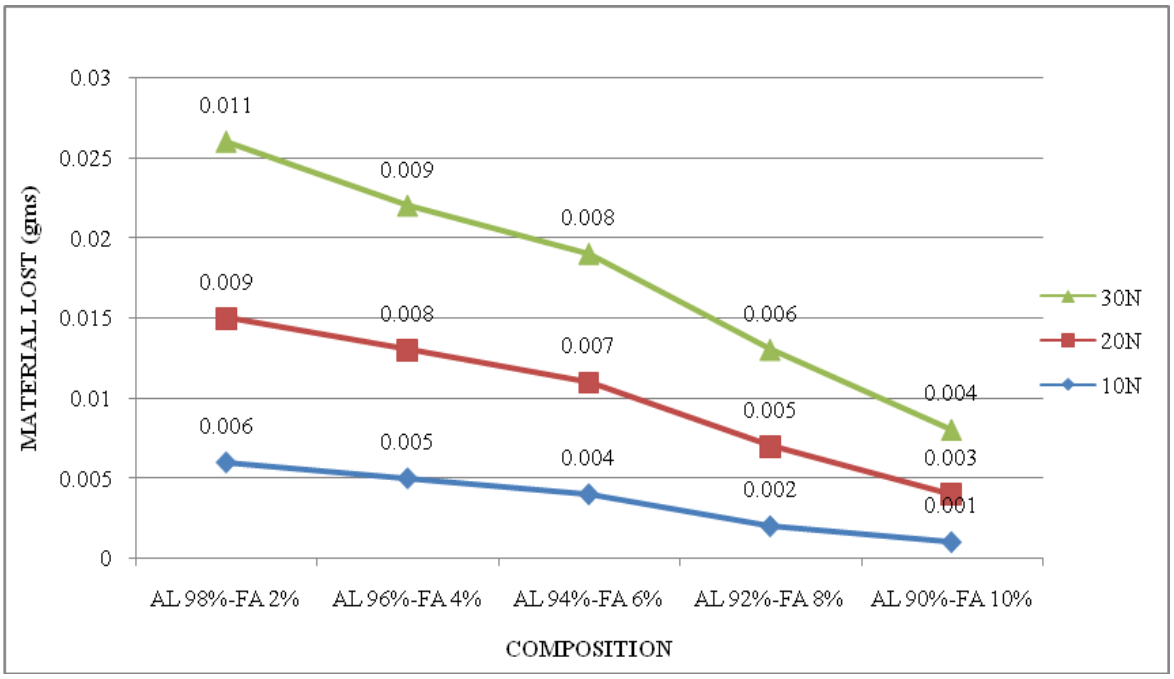

Fig 1.7 Graphical representations of wear rate values.

It is observed from graphs that are composition of fly ash in composite increases the density decreases.

Table 1.3 Corrosion rate of composites

S.No.	Composition by weight percentage	Material loss in grams				
		1hr	2hr	3hr	4hr	5hr
1	Al 98%- FA 2%	0.065	0.397	0.512	0.674	0.765
2	Al 96%- FA 4%	0.035	0.142	0.246	0.361	0.422
3	Al 94%- FA 6%	0.03	0.062	0.169	0.307	0.397
4	Al 92%- FA 8%	0.028	0.035	0.095	0.179	0.204
5	Al 90%- FA 10%	0.002	0.008	0.029	0.046	0.067

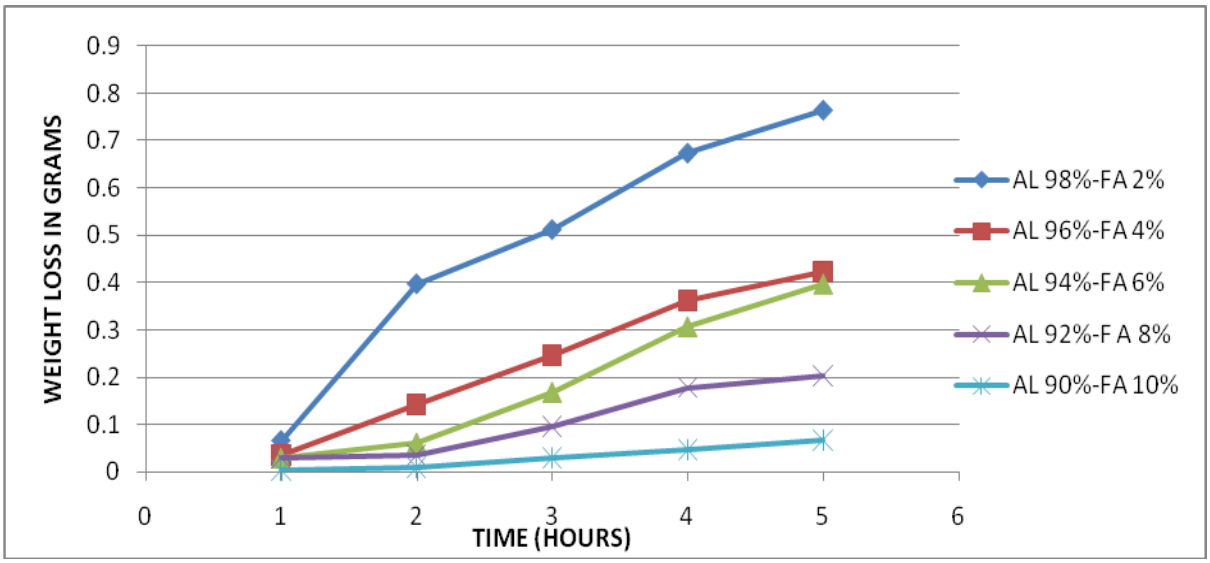

Fig 1.8 Graphical representation of corrosion rate values

It is observed from graph that if the composition of fly ash in composite increases the corrosion rate decreases.

DENSITY TEST:

Table 1.4 Density variation of composites

S.No.	Composition by weight percentage	Density gm/cc
1	Al 100 % - FA 0 %	2.78
2	Al 98 % - FA 2 %	2.74
3	Al 96 % - FA 4%	2.63
4	Al 94 % - FA 6%	2.54
5	Al 92 % - FA 8 %	2.49
6	Al 90 % - FA 10 %	2.41

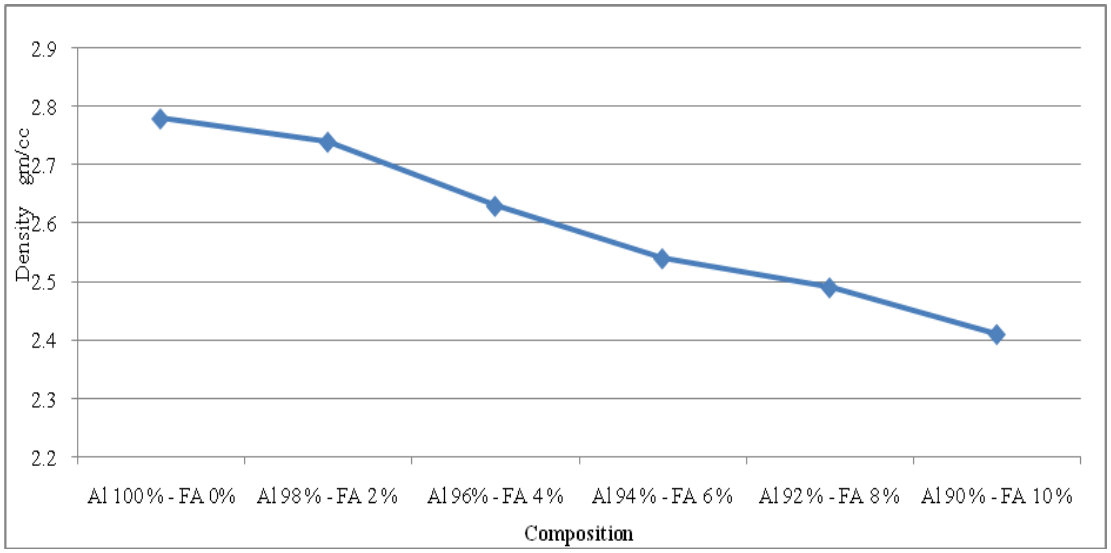

Fig 1.9 Graphical representation of Density values

It is observed from graph that if the composition of fly ash in composite increases the density decreases.

CONCLUSION

Aluminium 2024- Fly ash metal matrix composites were fabricated successfully by using powder metallurgy technique. In this observed fly ash composition is raised up to 10% hardness is increased and density, corrosion & wear rate are reduced. From this, we said aluminium alloy 2024 has mixed with fly ash is very good. So, It has given good results on mechanical properties

From this study it was concluded that industrial waste fly ash was turn into industrial wealth by the production of light weight composites with higher strength, these light weight Aluminium Fly ash composites can be used for automobile industries and aeroplanes.

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