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Mechanical Behaviour of Aluminium-2024 Reinforced with Fly ash Synthesized by Stir Casting

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***Abstract*:- Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersoids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste byproduct during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to over come the cost barrier for wide spread applications in automotive and small engine applications. It is therefore expected that the incorporation of fly ash particles in aluminium alloy will promote yet another use of this low-cost waste by-product and, at the same time, has the potential for conserving energy intensive aluminium and thereby, reducing the cost of aluminium products. aluminium matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. The present investigation has been focused on the utilization of abundantly available industrial waste fly- ash in useful manner by dispersing it into aluminium to produce composites by stir casting method. Now a days the particulate reinforced**

Keywords—Composites, Al-2024,Fly ash,Microstructure, Tribological Behaviour.

INTRODUCTION

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersoids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to over come the cost barrier for wide spread applications in automotive and small engine applications. It is therefore expected that the incorporation of fly ash particles in aluminium alloy will promote yet another use of this low-cost waste by-product and, at the same time, has the potential for conserving energy intensive aluminium and thereby, reducing the cost of aluminium products

Now a days the particulate reinforced aluminium matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. Cast aluminium matrix particle reinforced composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys .While investigating the opportunity of using fly-ash as reinforcing element in the aluminium melt, R.Q.Guo and P.K.Rohatagi observed that the high electrical resistivity, low thermal conductivity and low density of fly-ash may be helpful for making a light weight insulating composites. The particulate composite can be prepared by injecting the reinforcing particles into liquid matrix through liquid metallurgy route by casting. Casting route is preferred as it is less expensive and amenable to mass production. Among the entire liquid state production routes, stir casting is the simplest and cheapest one. The only problem associated with this process is the non uniform distribution of the particulate due to poor wet ability and gravity regulated segregation.

Mechanical properties of composites are affected by the size, shape and volume fraction of the reinforcement, matrix material and reaction at the interface. These aspects have been discussed by many researchers. Rohatgi reports that with the increase in volume percentages of fly ash, hardness value increases in Al–fly ash (precipitator type) composites. He also reports that the tensile elastic modulus of the ash alloy increases with increase in volume percent (3–10) of fly ash. Aghajanian et al. have studied the Al2O3 particle reinforced Al MMCs, with varying particulate volume percentages (25, 36, 46, 52 and 56) and report improvement in elastic modulus, tensile strength, compressive strength and fracture properties with an increase in the reinforcement content. The interface between the matrix and reinforcement plays a critical role in determining the properties of MMCs. Stiffening and strengthening rely on load transfer across the interface.

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Toughness is influenced by the crack deflection at the interface and ductility is affected by the relaxation of peak stress near the interface.

Extensive studies on the tribological characteristics of Al MMCs containing reinforcements such as SiC and Al2O3 is available in the literatures. However, reports on friction and wear characteristics of fly ash reinforced AMCs are very limited. Rohatgi has reported that the addition of fly ash particles to the aluminium alloy significantly increases its abrasive wear resistance. He attributed the improvement in wear resistance to the hard aluminosilicate constituent present in fly ash particles.

EXPERIMENTAL WORK

First of all, 400 gm of commercially pure aluminium was melted in a resistance heated muffle furnace and casted in a clay graphite crucible. For this the melt temperature was raised to 993K and it was degassed by purging hexachloro ethane tablets. Then the aluminium-fly ash (4%) composites were prepared by stir casting route. For this we took 400 gm of commercially pure aluminum and then (4) wt% of fly ash were added to the Al melt for production of composites. The fly ash particles were preheated to 373K for two hours to remove the moisture. Commercially pure aluminium was melted by raising its temperature to 993K and it was degassed by purging hexachloro ethane tablets. Then the melt was stirred using a mild steel stirrer. Fly-ash particles were added to the melt at the time of formation of vortex in the melt due to stirring. The melt temperature was maintained at 953K993K during the addition of the particles. Then the melt was casted in a clay graphite crucible. The particle size analysis and chemical composition analysis was done for fly ash. The hardness testing and density measurement was carried out Al-(4)) wt% fly ash composites. The hardness of the samples was determined by Brinell hardness testing machine with 750 kg load and 5 mm diameter steel ball indenter. The detention time for the hardness measurement was 15 seconds. The wear characteristics of Al-fly ash composites were evaluated using wear testing machine.

For this, cylindrical specimens of 1.1 cm diameter and

2.1 cm length were prepared from the cast Al- fly ash composites. Test was performed at under different loads and rpm for 10 minutes. The SEM was done for all the samples.

WORKS DONE:

1. Commercially pure Al was melted and casted.
2. Al-(4%)fly ash composite was fabricated by stir casting method.
3. Particle size analysis was done for fly ash used.
4. Hardness measurement was carried out for Al-fly ash composite samples
5. SEM analysis was done for all the Al-fly ash composite samples, Fly-ash and worn surfaces.

Table : Chemical Composition of Al- 2024 alloy

Element	Percentage
Cu	4.5
Si	0.45
Mg	1.6
Zr	0.10
Fe	0.25
Mn	0.40
Cr	0.05
Zn	0.2
Al	Balance

FLY ASH

Fly ash is one of the residues generated in the combustion of coal. It is an industrial byproduct recovered from the flue gas of coal burning electric power plants. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all fly ash includes substantial amounts of silica (silicon dioxide, SiO_2) (both amorphous and crystalline) and lime (calcium oxide, CaO). In general, fly ash consists of SiO2, Al2O3, Fe2O3 as major constituents and oxides of Mg, Ca, Na, K etc. as minor constituent. Fly ash particles are mostly spherical in shape and range from less than 1 µm to 100 µm with a specific surface area, typically between 250 and 600 m^2/kg. The specific gravity of fly ash vary in the range of 0.6-2.8 gm/cc. Coal fly ash has many masonry blocks, as a concrete admixture, as a material in lightweight alloys, as a concrete aggregate, in flowable fill materials, in roadway/runway construction, in structural fill materials, as roofing granules, and in grouting. The largest application of fly ash is in the cement and concrete industry, though, creative new uses for fly ash are being actively sought like use of fly ash for the fabrication of MMCs.

Table: Chemical analysis of fly ash

COMPOUNDS	PERCENTAGE(%)
SiO2	67.2
Al2O3	29.6
Fe2O3	0.1
CaO	1.4
MgO	1.7

CHEMICAL REACTION BETWEEN Al AND FLY ASH

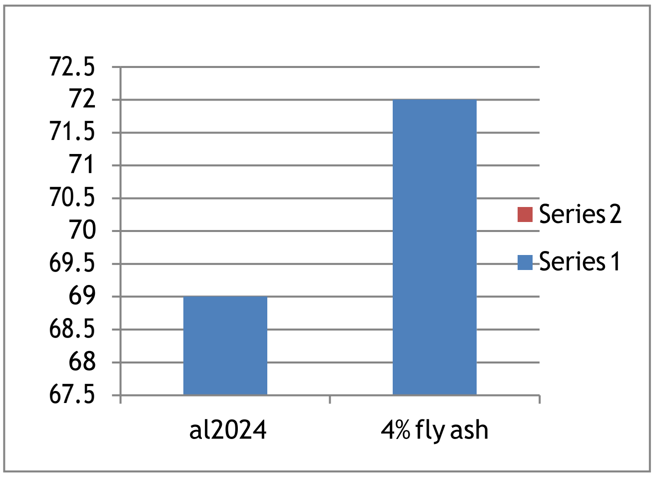
The thermodynamic analysis indicates that there is possibility between the reaction of Al melt and the fly ash particles. The particles contain alumina, silica and iron oxide which during solidification process of Al fly ash composites or during holding such composites at temperature above 850^0 C, are likely to undergo chemical reactions, reported by P.K.Rohatagi and Guo. The experiments indicate that there is a progressive reduction between SiO_2, Fe_2O_3 and mullite by Al and formation of Al_2O_3, Fe and Si. The wall of uses including as a cement additive, in cenosphere fly ash particles progressive disintegrates into discrete particles into the reaction progress.

TESTING OF COMPOSITES

Microstructure study has been carried out on the prepared composite using Vegas Tescan made scanning electron microscope. Basically the test samples of 10-12mm in diameter are cut from the prepared castings using lathe machine and are polished thoroughly as already mention methods it is etched using reagent for better results. The polished specimens which looks like mirror. The specimens are characterized for various magnifications (100X, 200X, 800X) to indicate distribution of reinforcements in metal matrix

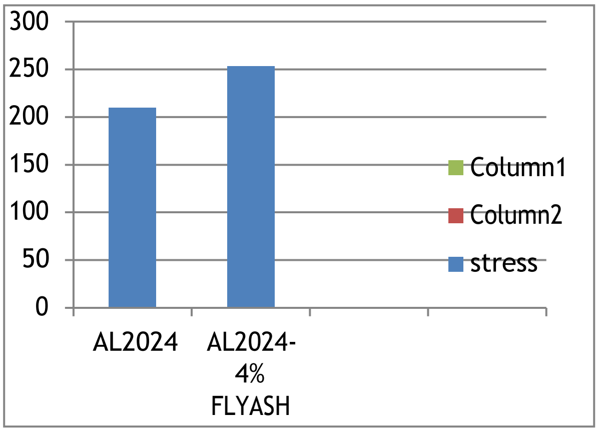
RESULTS & DISCUSSION

HARDNESS MEASUREMENT

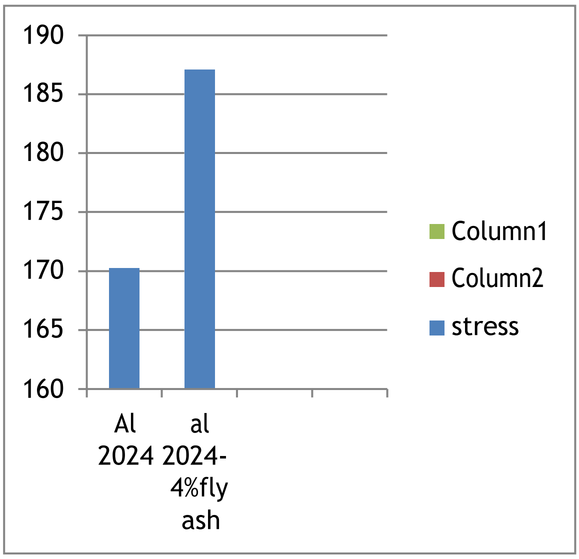


The above table shows that incorporation of fly ash particles in Aluminium matrix causes reasonable increase in hardness. The strengthening of the composite can be due to dispersionstrengthening as well as due to particle reinforcement.Thus, fly ash as filler in Al casting reduces cost, decreases density and increase hardness which are needed in various industries like automobile etc

Ultimate Tensile strength



Yield Strength



SEM ANALYSIS

SEM photographs were taken to analyze the fly ash particles and surfaces of Al-(4%) fly ash composites.

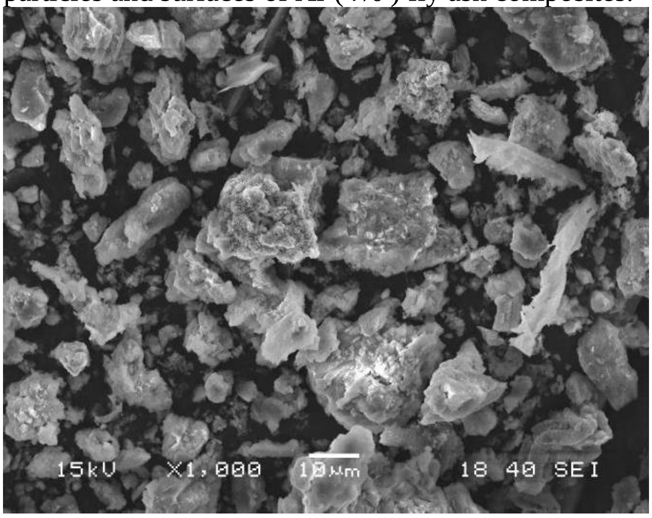


FIG 4.5 (a) SEM micrograph of Al 2024

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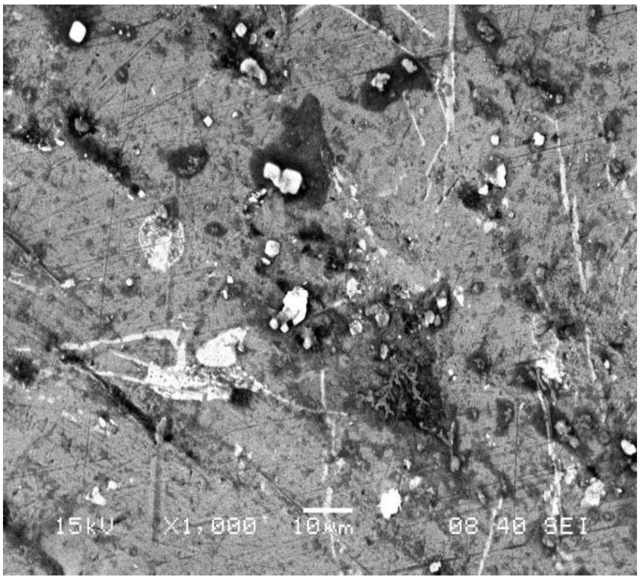

b)SEM micrograph of Al 2024,4%fly ash

CONCLUSION

1. From the study it is concluded that we can use fly ash for the production of composites and can turn industrial waste into industrial wealth. This can also solve the problem of storage and disposal of fly ash.
2. Fly ash upto 20% by weight can be successfully added to Al by stir castingroute to produce composites.
3. The hardness of Al-fly ash composites has increased with increase in addition of fly ash.
4. the frictional forces has decreased significantly with the incorporation of fly ash in Al melt.
5. Strengthening of composite is due to dispersion strengthening, particle reinforcement and solid solution strengthening.

REFERENCES

[1] P.K. Rohatgi, JOM 46 (11) (1994) 55–59.
[2] T.P.D. Rajan, R.M. Pillai, B.C. Pai, K.G. Satyanarayana, P.K. Rohatgi, Proceedings of National Conference on: Recent Advances in Materials Processing (RAMP-2001), India, 2001, pp. 327– 334.
[3] S. Skolianos, T.Z.Kattamis, Mater.Sci.Engg.A163 (1993) 107.
[4] M.K.Surappa, S.C.Prasad, Wear 77 (1982) 295.
[5] R.Q.Guo, P.K.Rohatgi, Fuel and energy Abstracts, (1997) 828.
[6] M.K. Aghajanian, R.A. Langensiepen, M.A. Rocazella, J.T. Leighton, C.A. Andersson, J. Mater. Sci. 28 (1993) 6683–6690.
[7] T.W. Clyne, P.J. Withers, An Introduction to Metal Matrix Composites, Cambridge University Press, Cambridge, UK, 1993, pp. 166–217.
[8] E.A. Feest, Composites 25 (1994) 75–86.
[9] T.P.D. Rajan, R.M. Pillai, B.C. Bai, J. Mater. Sci. 33 (1998) 3491–3503.
[10] L. Cao, Y. Wang, C.K. Yao, The wear properties of an SiC–whisker reinforced aluminium composite, Wear 140 (1990) 273–277.
[11] Manish Narayan, M.K. Surappa, B.N. Pramila Bai, Dry sliding wear of Al alloy 2024–Al2O3 particle metal matrix composites,Wear 181–183 (1995) 563–570.
[12] A. Ravikiran, M.K. Surappa, Oscillations in coefficient of friction during dry sliding of A356 Al-30% wt. SiCp MMC against steel, Scripta Mater. 36 (1997) 95–98.
[13] Composite Materials: Engineering and Design by F.L.Matthews and R.D.rawlings, Chapman & Hall publication.