Fabrication and Analysis of Aluminium Fly Ash Composite using Electro Chemical Machining

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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 by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome 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 aluminum 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 aluminum and thereby, reducing the cost of aluminum products. Now a days the particulate reinforced aluminum 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 aluminum to produce composites by stir casting method.

Keywords: Stir casting method, Electrochemical Micromachining, Taguchi, L9, Metal Matrix Composite, Material removal rate, Overcut

I. 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 overcome 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 aluminum 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 aluminum and thereby, reducing the cost of aluminum products .

Now a days the particulate reinforced aluminum 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 aluminum 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 aluminum 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.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. 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 aluminum alloy significantly increases its abrasive wear resistance. He attributed the improvement in wear resistance to the hard aluminosilicate constituent present in fly ash particles.

II. EXPERIMENTAL SETUP

The EMM setup has been fabricated in-house .The setup mainly consists of various components, such as mechanical machining unit, tool electrode feeding system, inter-electrode gap control system, electrolyte supply system, and pulsed power supply system. The electrolyte supply and cleaning system consist of a pump and a filter. A pulsed power supply of 20 V and 30 A with the capability for varying voltage, current, and pulse width was used. The experiments were conducted using stainless steel electrode of φ0460 μm, sodium nitrate of varying concentrations used as electrolytes, and copper work piece of thickness of 200 μm. The experimental factors we are selected based on the above.

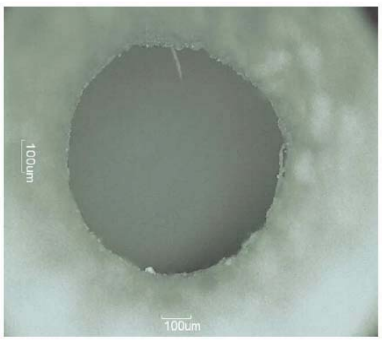
Table.1 Machining parameters and their levels

Symbol	Factor	Level -1	Level-2	Level-3
A	Electrolyte concentration(g/l)	22	27	32
B	Machining voltage(v)	9	11	13
C	Duty cycle(percentage)	50	40	65
D	Frequency(Hz)	55	65	75

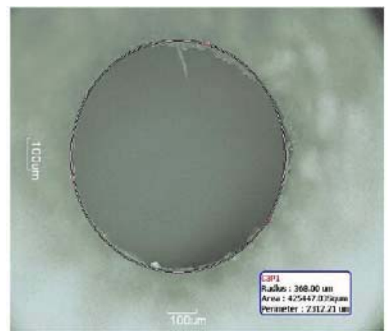
Electrolyte concentration(g/l)	Machining voltage(v)	Duty cycle(percentage)	Frequency(Hz)
22	9	50	55
22	11	40	65
22	13	65	75
27	9	40	75
27	11	65	55
27	13	50	65
32	9	65	65
32	11	50	75
32	13	40	130

Table.2 Readings taken by micro drilling

Micro drilled plate



Micro hole without dimension

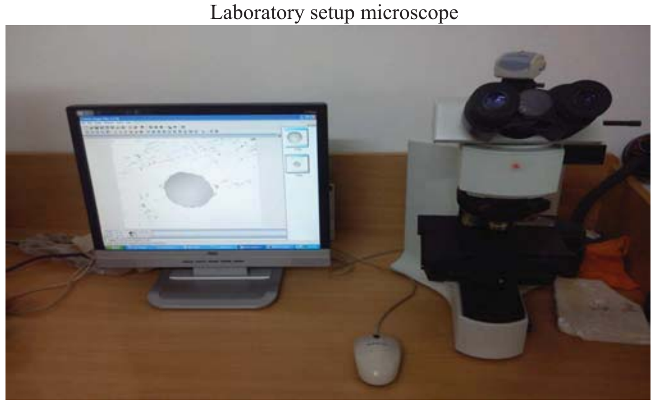


Micro hole with dimension

electrolyte concentration(g/l)	machining voltage(v)	duty cycle(%)	frequency(Hz)	over cut(um)	SNRA2	MEAN2
22	9	50	55	212	-46.52671722	212
22	11	40	65	138	-42.79758173	138
22	13	65	75	282	-49.00498217	282
27	9	40	75	252	-48.02801082	252
27	11	65	55	198	-45.93330381	198
27	13	50	65	248	-47.88903362	248
32	9	65	65	180	-45.1054501	180
32	11	50	75	164	-44.29687696	164
32	13	40	130	130	130	130

Table.3 S/N ratio for overcut by Taguchi method

Laboratory setup microscope

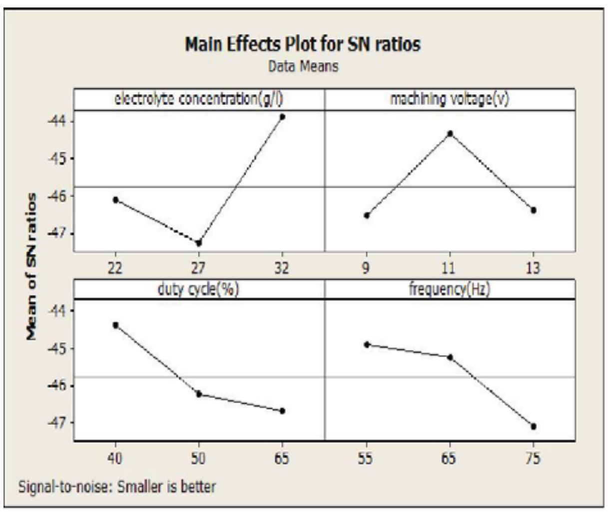


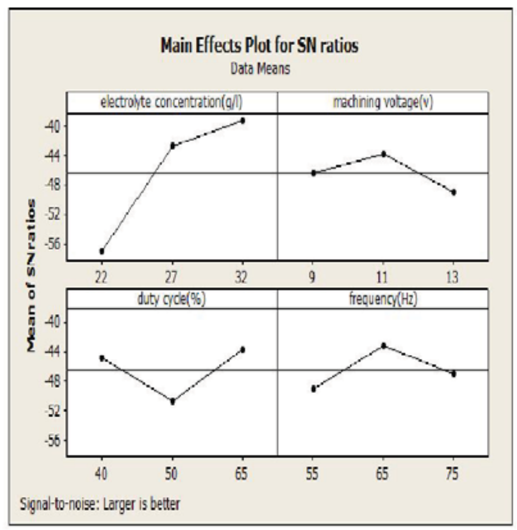
electrolyte concentration(g/l)	machining voltage(v)	duty cycle(%)	frequency(Hz)	over cut(um)	SNRA2	MEAN2	MRR(mg/min)	SNRA1	MEAN1
22	9	50	55	212	-46.5267	212	0.000625	-64.0824	0.000625
22	11	40	65	138	-42.7976	138	0.00324	-49.7891	0.00324
22	13	65	75	282	-49.005	282	0.00133	-57.523	0.00133
27	9	40	75	252	-48.028	252	0.00823	-41.692	0.00823
27	11	65	55	198	-45.9333	198	0.00975	-40.2199	0.00975
27	13	50	65	248	-47.889	248	0.0048	-46.3752	0.0048
32	9	65	65	180	-45.1055	180	0.02125	-33.4528	0.02125
32	11	50	75	164	-44.2969	164	0.00818	-41.7449	0.00818
32	13	40	55	130	-42.2789	130	0.007142	-42.9236	0.007142

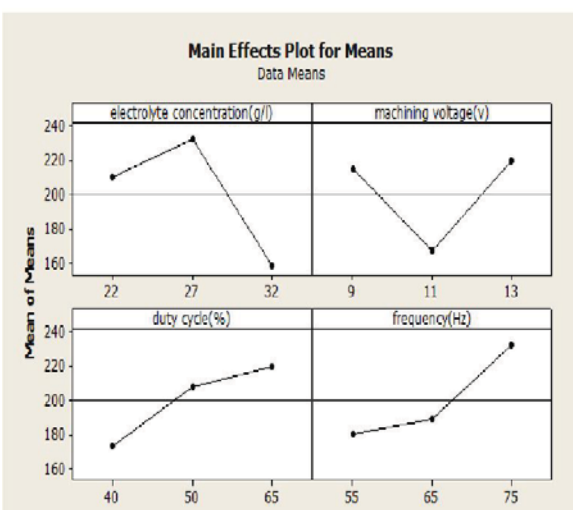
Table.4 S/N ratio for MRR by Taguchi method

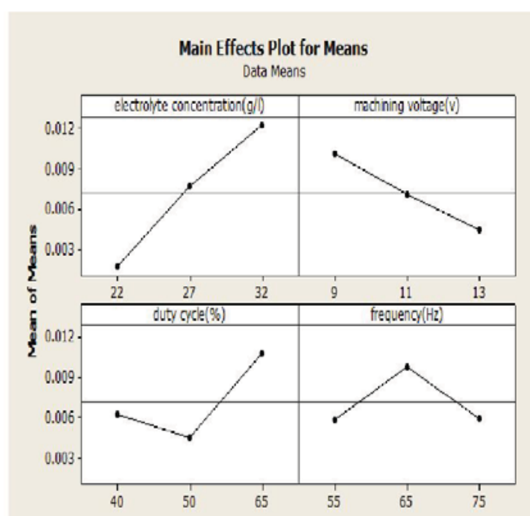
III. RESULTS

S/N ratio for overcut by four factors: fig (a)









S/N ratio for MRR by four factors: fig (a)

IV. 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 up to 20% by weight can be successfully added to Al by stir casting route to produce composites.
3. The hardness of Al-fly ash composites has increased with increase in addition of fly ash.
4. EMM setup
   - Successfully utilized
   - Fulfill the requirement and the need of Micromachining Operations
5. The optimal values for minimum overcut were electrolyte concentration of 23 g/l, machining voltage of 13 V, frequency of 75 Hz, and duty cycle 65 %.

6. The optimal values for maximum MRR were electrolyte concentration of 33 g/l, machining voltage of 9 V, frequency 65 Hz, and duty cycle 65 %.

7. Based on the F value, the most significant parameters that influence the overcut and MRR are found to be electrolyte concentration and frequency, respectively.

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] P.K. Rohatgi, R.Q. Guo, P. Huang, S. Ray, Metall. Mater. Trans. A 28 (1997) 245–250.
[4] Akbulut, M. Darman, F. Yilmaz, Wear 215 (1998) 170.
[5] S. Skolianos, T.Z.Kattamis, Mater.Sci.Engg.A163 (1993) 107.
[6] M.K.Surappa, S.C.Prasad, Wear 77 (1982) 295.
[7] R.Q.Guo, P.K.Rohatgi, Fuel and energy Abstracts, (1997) 828.
[8] R.Q.Guo, P.K.Rohatgi, Fuel and energy Abstracts, (1997) 157.
[9] M.J.Koczak, M.K.Prem Kumar, JOM 45 (1993) 44.
[10] P.C.Maity, P.N.Chakraborty, S.C.Panigrahi, Scripta Metall. Mater. 28 (1993) 549.
[11] K. Aghajanian, R.A. Langensiepen, M.A. Rocazella, J.T. Leighton, C.A. Andersson, J.Mater. Sci. 28 (1993) 6683–6690.
[12] T.W. Clyne, P.J. Withers, An Introduction to Metal Matrix Composites, Cambridge University Press, Cambridge, UK, 1993, pp. 166–217 .