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A Review:Engineering application of Metal Matrix Composites.

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ABSTRACT

Metal matrix composites possessto develop new structural materials with higher strength to weight ratios is one of the biggest challenges in the aerospace as well as various industry. The Properties like high specific strength, stiffness, better wear resistance ie excellent physical and mechanical properties. The filler reinforcement into the metallic matrix improves the stiffness, specific strength, wear, creep and fatigue properties compared to the conventional engineering materials.

KEYWORDS: Aluminium metal matrix composites, Reinforcement.

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INTRODUCTION

MMCs (Metal matrix composites) uses metal matrix dispersed with other metal, ceramic or organic compounds. Reinforcements are usually done to improve the various properties of the base metal. The particle distribution plays a very important role in the properties of MMCs. Copper, Magnesium and Aluminium has attracted most attention as base metal in metal matrix composites.These MMCs are widely used in aircraft, aerospace, automobiles, defence and various other fields . The most commonly used reinforcements are Silicon Carbide (SiC), TiO_2, Aluminium Oxide (Al_2O_3), B_4C, Y_2O_3, Si_3N_4, AlN[3,4,5,6,7]. Al_2O_3 reinforcement shows good compressive strength and wear resistance. Boron Carbide is one of hardest known elements. It has high fracture toughness and elastic modulus. The addition of Boron Carbide (B_4C) in MMCs increases their hardness, but does not improve the wear resistance significantly. Fibers play very important role as reinforcement, as they transfer strength to the matrix which results in the enhancement of their physical and mechanical properties as desired. Zircon is usually used in hybrid reinforcement for improving the wear resistance. In the last decade, lot of work has been done on fly ash reinforced MMCs. Due to their low cost and availability as waste by-product in thermal power plants. It improves the electromagnetic shielding effect of the MMCs . Based on the stated potential benefits of MMCs this paper investigates the affect of various dispersion on the mechanical properties of MMCs, processing methodology and their applications. MMCs using several metallic materials as matrix have been studied by many researchers. Among all, the most interesting metals for industrial applications are Al, Mg, Ti, Cu and their alloys. Pure and alloyed aluminium is the most investigated material as matrix in MMCs. Al-based composites are good candidates for structural application. Various nano-sized oxides like (Al_2O_3, Y_2O_3), nitrides (Si_3N_4, AlN) , carbides (TiC,SiC) , hydrates (TiH_2) and borides (TiB2)have been used as dispersion. As ceramic reinforcements Carborundum, Sic and alumina are widely used in these MMCs. Moreover, different allotropes of carbon like carbon black, fullerenes and carbon nanotubeshave also been investigated by several researchers. CNTs are potential candidates as they confer very high mechanical properties to the metal matrix. They also increase the electrical conductivity, which makes MMCs very attractive materials for electrical applications. Single wall carbon nano tubes (SWCNT) and multi wall carbon nano tubes (MWCNT) both are used as reinforcement in MMCs. Copper-0.1 wt.% MWCNT composites revealed a 47% increase in hardness and bronze-0.1 wt.% SWCNT showed a 20% improved electrical conductivity [18,19]. Intermetallic compounds like (NiAl, Al_3Ti) have also been dispersed in MMCs [15-19]. Al–Al_3Ti nano composite showed good mechanical properties at high temperature [17-20].

1. ALUMINIUM OXIDE REINFORCED AMC:

Abouelmagd.G[21]studied the hot deformation and wear resistance of powder metallurgy aluminium metal matrix composites. It was found that the addition ofAl_2O_3 andAl_4C_3 increases the hardness and compressive strength. The addition ofAl_4C_3 improved the wear resistance of the MMC.

Tjong.et.al. S.C[22]compared the properties of two aluminium metal matrix composites,Al-B_2O_3-TiO_2 system and Al-B-TiO_2 system. It was found that the reactive hot pressing of the composites resulted in the formation of ceramic Al_2O_3 and TiB_2 particulates as well as coarse intermetallicAl3Ti blocks.Al-B-TiO2 had higherAl3Ti content and showed high tensile strength, but low tensile ductility.Al-B_2O_3-TiO_2 had more fatigue strength than Al-B-TiO_2.

Kok.M[23] fabricated the Al_2O_3 particle reinforced 2024 Al alloy composites by vortex method and studied their mechanical properties and found the optimum conditions of the production process with a pouring temperature of 700 ^{0}C, preheated mould temperature of

550 ^{0}C, stirring speed of 900 rev/min, particle addition rate of 5 g/ min, stirring time of min and with a applied pressure of 6 MPa. The wettability and the bonding between Al alloy/Al_2O_3 particles were improved by applied pressure but porosity will be decreased by this pressure.

Kannan and Kishawy.S[24]conducted orthogonal cutting tests to study the effect of cutting parameters and particulate properties on the micro-hardness variations on the machined Al2O3 particulate reinforced AMC. They found that themicro- hardness is higher near the machined surface layer.Micro-hardness variations were higher for low volume fraction and coarse particles.

Park.B.G. et.al.[25] investigated the effect of Al_2O_3 in Aluminium for volume fractions varying from 5-30% and found that the increase in volume fraction of Al_2O_3 decreased the fracture toughness of the MMC. This is due to decrease in inter-particle spacing between nucleated micro voids.

Park et al.[26] investigated the high cycle fatigue behavior of 6061 Al-Mg-Si alloy reinforced Al_2O_3 microspheres with the varying volume fraction ranging between 5%and 30%. They found that the fatigue strength of the powder metallurgy processed composite was higher than that of the unreinforced alloy and liquid metallurgy processed composite.

Kumar.Abhisheket.al.[27] experimentally investigated the characterization ofA359/Al_2O_3MMC using electromagnetic stir casting method. They found that the hardness and tensile strength of MMC increases and electromagnetic stirring action produces MMC with smaller grain size and good particulate matrix interface bonding. That why tensile strength and hardness of the composite increased.

2. FLY ASH REINFORCED AMC:

Fly ash particles are potential discontinuous dispersoids used in metal matrix composites due to their low cost and low density reinforcement which are available in large quantities as a waste by product in thermal power plants. Addition of fly ash particle as reinforcement in MMCs is advantageous for obtaining higher structural homogeneity with minimum possible porosity levels, good interfacial bonding, higher mechanical strength, uniform distribution of reinforcement and act as a load bearing constituents[28-31]. The major constituents of fly ash are SiO_2, Al_2O_3, Fe_2O_3, and CaO. Rajanet al.[32] compared the effect of the three different stir casting methods on the properties of fly ash particles reinforced Al-7Si-0.35Mg alloy. The three stir casting methods are liquid metal stir casting, compo-casting and modified compo-casting followed by squeeze casting. The compression strength of the composite fabricated by modified compo-casting cum squeeze casting is improved compared to the matrix alloy. However, the tensile strength was found to be reduced. A well dispersed and porosity free fly ash particle dispersed composite was produced by the modified compo-casting cum squeeze casting process. The electromagnetic interference shielding effectiveness properties of the 2024.Al alloy-fly ash composites was investigated by Dou et al.. The composite have effective shielding property in the frequency range of 30 KHz- 1.5 GHz. But, the tensile strength of the composites decreased with the addition of fly ash particulate. Ramachandra.et al. experimentally found that the wear resistance of Al MMC increases with the increase in fly ash content, but decreases with increase in normal load and sliding velocity, and also observed that the corrosion resistance decreases with the increase in fly ash content.

3.PREPARATION METHODS AND PROPERTIES:

Preparation of MMCs by conventional casting processes results in an inhomogeneous distribution of particles within the matrix due to low wettability of ceramic nano-particles. For the large-scale production of metal matrix nano composites, the main problem to face is the low wettability of ceramic nano-particles, which does not allow the preparation of MMCs by conventional casting processes since the result would be an inhomogeneous distribution of particles within the matrix. The high surface energy results in the agglomeration of nano particles, which are not effective in hindering the movement of dislocations and can hardy generate a physical-chemical bond to the matrix, thus reducing significantly the strengthening capability of nano particles. Several preparation methods have been adopted by researchers to overcome the wettability issue, either by formation of the reinforcement by in situ reaction or by ex situ addition of the ceramic reinforcement by different techniques.

4.SOLID STATE FABRICATIONMETHODS:

Table 1: Properties and applications:

Sl..No 1	Methods 2	Applications 3	Properties 4	Value 5
1	Vapor deposition techniques	Aerospace, Automotive, Surgical/Medical Dies and moulds for all manner of material processing. Cutting tools, Firearms Optics Watches, Thin films (window tint, food packaging, etc.)	PVD coatings are sometimes harder and more corrosion resistant than coatings applied by the electroplating process.	Average
2	Powder Metallurgy	Production of small objects (especially round), bolts, pistons, valves, high-strength and heat-resistant materials. Vast applications in automotive, aircraft, defense, sports and appliance industries.	Both matrix and reinforcements used in powder form. Best for particulate reinforcement.	Average
3	Friction stir Process	In Automotive and Aerospace applications.	Used as surface modification process. Increase in micro hardness of the surface, significant improvement in wear resistance.	Costly
4	Diffusion Bonding	Manufacture sheets, blades, vane, shafts, and structural components.	Handles foils or sheets of matrix and filaments of reinforcing element.	Expensive

5.POWDER METALLURGYMETHOD: Powder metallurgy is the process of blending fine powdered materials, pressing them into a desired shape (compacted), and then heating the compressed material in a controlled atmosphere to bond the material (sintering). The powder metallurgy process generally consists of four basic steps: (1) powder manufacture, (2) powder mixing and blending, (3) compacting, (4) sintering. Compacting is generally performed at room temperature, and the elevated-temperature process of sintering is usually conducting at atmospheric pressure.

CONCLUSION:

The different techniques are used for the preparation of MMCs. Metal matrix nano composites have a lot of potential to be used in a large number of industrial applications.It was found that the addition ofAl_2O_3 andAl_4C_3 increases the hardness and compressive strength and addition ofAl_4C_3 improved the wear resistance of the MMC.The increase in reinforcement ratio and decrease in reinforcement particle size significantly improves the mechanical and fatigue properties of AMCs. The addition of fly ash particles as reinforcement is advantages for obtaining high structural homogeneity in AMCs.In terms of hardness, mechanical strength, creep behavior and damping properties they also proved to be excellent. Adoption of these metal matrix composites, could be a good replacement of expensive conventional monolithic alloys used for structural and functional applications.

REFERENCE

1. Tjong, S.C, KC Lau, SQ Wu ,:Wear of Al-based hybrid composites containing BN and SiC particulates. Metall Mater Trans A 1999; 30(9): 2551- 2555.
2. T Rajmohan, K Palanikumar, S Ranganathan : Evaluation of mechanical and wear properties of hybrid aluminium matrix composites. Trans Nonferrous Met Soc China2013; 23(9): 2509-2517.
3. VijayaRamnath B, C Elanchezhian, M Jaivignesh, S Rajesh, C Parswajinan, et al. : Evaluation of mechanical properties of aluminium alloy– alumina–boron carbide metal matrix composites. Mater Des,2014; 58: 332- 338.
4. Ravindran P,Manisekar K, S Vinoth Kumar, P Rathika: Investigation of microstructure and mechanical properties of aluminum hybrid nano-composites with the additions of solid lubricant. Mater Des 2013; 51: 448-456.
5. N Panwar, A Chauhan :Development of aluminum composites using Red mud as reinforcement – a review. Engineering and Computational Sciences (RAECS)2014; 1-4.
6. Gikunoo, O Omotoso,Oguocha,INA : Effect of fly ash particles on the mechanical properties of aluminium casting alloy A535. MatSciTechnol, 2005; 21(2): 143-152.
7. Rohatgi PK, A Daoud, BF Schultz, TPuri: Microstructure and mechanical behavior of die casting AZ91D-Fly ash cenosphere composites. Compos Part Appl. Sci.Manuf 2009; 40(6-7): 883-896.
8. VenkatPrasat, R Subramanian:Tribological properties of AlSi10Mg/fly ash/graphite hybrid metal matrix composites. Ind.Lubr.Tribol2013; 65(6): 399-408.
9. Moorthy A, DN Natarajan, R Sivakumar, M Manojkumar, M Suresh: Dry sliding wear and mechanical behavior of aluminium/fly ash/ graphite hybrid metal matrix composite using taguchi method. Int J Mod Eng Res IJMER,2012; 2(3): 1224-1230.
10. David Raja Selvam J, DS Robinson Smart, IDinaharan: Synthesis and characterization of Al6061-Fly Ashp-SiCp composites by stir casting and compocasting methods. Energy Procedia,2013; 34: 637-646.
11. Escalera-Lozano. R, CA Gutiérrez, MA Pech-Canul, MI Pech-Canul:Corrosion characteristics of hybrid Al/SiCp/MgAl2O4 composites fabricated with fly ash and recycled aluminium. Mater Charact2007; 58(10): 953-960.

12. Alaneme KK, BO Ademilua, MO Bodunrin: Mechanical properties and corrosion behaviour of aluminium hybrid composites reinforced with silicon carbide and bamboo leaf ash. TribolInd,2013; 35(1): 25-35.
13. Prasad DS, C Shoba, N Ramanaiah: Investigations on mechanical properties of aluminum hybrid composites. J Mater Res Technol2014; 3(1): 79-85.
14. Alaneme K.K, TM Adewale : Influence of rice husk ash – silicon carbide weight ratios on the mechanical behaviour of Al-Mg-Si alloy matrix hybrid composites. Tribol. Ind, 2013; 35(2): 163-172.
15. Alaneme K.K, EO Adewuyi: Mechanical behaviour of Al-Mg-Si matrix composites reinforced with alumina and bamboo leaf ash. Metall Mater Eng.,2013;19(3): 177-187.
16. AlanemeK.K , TM Adewale, PA Olubambi : Corrosion and wear behaviour of Al-Mg-Si alloy matrix hybrid composites reinforced with rice husk ash and silicon carbide. J Mater Res Technol,2014; 3(1): 9-16.
17. Divecha AP, SG Fishman: Mechanical Properties of Silicon Carbide Reinforced Aluminum, in Proc. Conf. on Composite Materials,1979; 3: 351.
18. Dehong Lu, Yehua Jiang, Rong Zhou: Wear performance of nano- Al_2O_3 particles and CNTs reinforced magnesium matrix composites by friction stir processing Wear.,2013; 305(1-2): 286-290.
19. Amal M.K Esawi, Mostafa A El Borady :Carbon nanotube-reinforced aluminium strips. Composites Science and Technology,2008; 68: 486-492.
20. Hiroyuki Fukuda, KatsuyoshiKondoh, Junko Umeda, BunshiFugetsu: Interfacial analysis between Mg matrix and carbon nanotubes in Mg–6 wt.% Al alloy matrix composites reinforced with carbon nano tubes. Composites Science and Technology, 2011; 71: 705-709.
21. Abouelmagd.G // Materials Processing Technology2004; 155: 1395.
22. Tjong.S.C,Wang,G.S., Gen.L and Mai.Y.W // Composites Science and Technology,2004; 64,1971.
23. Kok. M // Materials processing Technology,2005; 161 , 381.
24. Kannan, S. and Kishawy.H.A : International Journal of Machine Tools & Manufacture,2006; 46; 2017.
25. Park. B.G, Crosky. A.G and Hellier. A.K // Composites: Part B,2008; 39: 1270.
26. Park. B.G, Crosky.A.G andHellier.A.K. // Composites: Part B,2008; 39: 1257.
27. Kumar. Abhishek, ShyamLal, Sudhir Kumar Noida, In: JMRTEC-40 (WHERE,WHEN),

28. Ogel, B., and Gurbuz, R., :"Microstructural characterization and tensile properties of hot pressed Al-SiC composites prepared from pure Al and Cu powders", Mater. Sci. Eng. A.,2001; 301; 213-220.
29. Onat, A., Akbulut, H., and Yilmaz, F., : "Production and characterization of silicon carbide particulate reinforced aluminium–copper alloy matrix composites by direct squeeze casting method", J. Alloys Compounds,2007; 436; 375–382.
30. Rohatgi, P., Guo, R. R.,: "Opportunities of using fly ash particles for synthesis of composites", Pro. of the 59th Annual American Power Conference, Chicago,1997; 828.
31. Rohatgi, P., Weiss, D., and Gupta, N.,: "Applications of fly ash in synthesizing low-cost MMCs for automotive and other applications", J. Miner. Metals Mater. Soc.,2006; 58:71-76.
32. Rajan T. P. D., Pillai, R. M., Pai, B. C., Satyanarayana K. G. and Rohatgi P. K., : "Fabrication and characterisation of Al–7Si–0.35Mg/fly ash metal matrix composites processed by different stir casting routes", Compos. Sci. Technol.,2007; 67: 3369-3377.
33. Dou, Z., Wu, G., Huang, X., Sun, D., and Jiang, L.:" Electromagnetic shielding effectiveness of aluminum alloy–fly ash composites", Composites Part A: Applied Science and Manufacturing,2007; 38: 186-191.
34. Ramachandra.M.andRadhakrishna K.: "Effect of reinforcement of flyash on sliding wear, slurry erosive wear and corrosive behavior of aluminium matrix composite", Wear, 2007,262,1450-1462.