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Composites Based on Aluminium Metal Matrix Prepared by Varies Methods with Their Mechanical and Tribological Properties – A Review

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Abstract: Aluminum based metal matrix composites (AMCs) are very useful and demanded in space and vehicle sector because they carry excellent properties like light weight, ductility, great strength, and toughness apart from this they can be handled by predictable methods. Melt casting and powder metallurgy methods are widely adopted for fabricating the compounds as compared to other technique. Casting methods is used for prepare the complex shapes because powder metallurgy technique is not able to prepare such type of complex shape though it is further cost effective than the melt casting techniques. Casting with stirring has certain advantages over powder metallurgy because it allows for better matrix particle adhesion, easier matrix structure control, low cost, simplicity, and the formation of precise shapes. The Casting process can be utilised with a wide range of materials. Aluminium metal matrix composites, on the other hand, have been found to have superior wear resistance and mechanical qualities. The tribological and mechanical properties of aluminium based alloy matrix composites manufactured using various casting processes are summarised in this review paper.

Keywords: Metal Matrix based on aluminium, Manufacture methods, mechanical and tribological characterization.

I. INTRODUCTION

Aerospace and automobile industries has tremendous demands of such type of material having good thermal stability and excellent specific strength. This demand can be fulfil by aluminum alloys reinforced with particles reinforcement [1, 2]. Another advantage of aluminum alloy is its light weight which gives economic advantages by decrease in weight[3-6]. The study has been carried out for determine the wear behaviour of composites based on aluminum matrix and found higher wear conflict properties with great secondary workability [7, 8]. Various factor generally used as a reinforced like carbides, nitrides and oxides with aluminium matrix. Mostly SiC and Al2O3 are used. Few research are based on B_4C reinforcement because of its high cost [11-17]. The composites reinforced by ceramic particulate exhibit improved abrasion resistance [18]. They are used in piston insert rings, cylinder blocks, pistons, brake disks etc. [19]. The composites strength is depends on the volume percentage and the reinforcement fineness [20]. Alalloy composites reinforced by ceramic particulate directed to generate of a new materials with better properties [21]. The type as well as size of the reinforcement is important for generate batter structure as well as excellent properties in to composites with nature of bonding [22-24].

II. FABRICATION TECHNIQUES

Different techniques can be used for making metal matrix composites. Liquid phase method (Costing), liquid-solid phase method, and powder metallurgy are the three types of processes [25, 26]. Powder metallurgy is often utilised in the fabrication of composites because it is more cost-effective than casting. When opposed to powder metallurgy, the wet processing approach, that includes the steering operation, produces a better outcome. Because of the better particle bonding, easier matrix structure control, and simplicity, a geometry that is closer to the desired shape can be created at a lower cost. The wet processing technique provides a wide range of materials. The downside of liquid casting is the need for reinforcing. The downside of a wet casting method is that the reinforcing nanoparticles are rarely inspected and tend to sink or float depending on their density Vidai Matrix liquid [27, 28].

Semi solid forming is a good manufacturing technology with the following benefits: complex forms may be made with near net shaping capabilities, process uses less energy, solidification shrinkage is reduced, die life is enhanced, and mechanical characteristics are enhanced [30, 31].

For generate highly viscous morphology grain, partially solids manufacturing requires several special techniques such like mechanical stirring, cooling slope method, and electromagnetic stirring, as well as the cooling slope casting method. It's widely used since it's easy and requires very little equipment, making it a cost-effective option [29-31].



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Baradeswaran et al. [2021] studied the effect (wear behaviour) of Graphite reinforcement on the aluminium 7075 / Al₂O₃/5wt. % graphite hybrid composite. Liquid metallurgy route is used to fabricate the composite. Solid lubricating material and ceramic particles were used with aluminium alloy matrix to reduce the wear as well as coefficient of friction value. They found by Increasing weight percent of ceramic the property (mechanical and tribological) of aluminium 7075+Al₂O₃+graphite composite increased as shown in fig(1). They also reported that the wear of the composite which contain graphite shows better resistance of wear [32]. Rao R. N. et al [2020] Fabricated aluminium Matrix composite with stair casting method and investigated the sliding wear under definite load and slipping speed [33]. By Taufik R. S. and Sulaiman S. [2020] proposed a model for the development of thermal expansion to cast aluminium silicon carbide [34]. F. Toptan et al. [2020] used Al-Si-Cu alloy matrix and B₄C particulates as a reinforcement toward produce the composite. They investigate corrosion behavior of the composed [35].

The tribological properties of the AA2124 metal Matrix composite were examined by M.B. Karams et al. [2019]. Using particles of different dimensions of SiC, B4C, or Al₂O₃ as reinforcement. Powder metallurgy were employed to manufacture the composites. They experiment with a 10% volume percentage of B_4C or SiC. This composite wear rate was discovered to be lower than that of the GGG40 cam material. They discovered that the composite having 30% volume concentration of 20 mm SiC had the finest wear performance, as seen in figure. 2, [36]. Researchers further discovered that B_4C at a 10% volume concentration had the highest performance. M.pugh and D. Cree [2011] A356 aluminium alloy and a hybrid composite of A356 aluminium alloy and silicon carbide foam were used in this project. Scientists used a ball on disc apparatus at room temperature to test the composite's dry sliding wear characteristics. Yusuf Shahin [2010] looked into the effects of an aluminium alloy matrix supplemented with 15% SiC particles. The composite was created using a powder metallurgy process. Table 1 shows the results of various research groups' investigations into the tribological and mechanical properties of aluminium alloy composites using various parameters and fabrication procedures [38].



Figure 1: (a). Hardness of graphite with varying percentages of graphite (b). Wear rate with varied graphite content percentages (c). Friction coefficients for varying graphite content percentages



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Figure 2: (a). The relationship among composite hardness and reinforcing volume fraction (b). Variation in specific wear as a function of reinforcing particle volume fraction

S.No.	Author details	Used Parameter	Synthesis	Tribological Test	Mechanical Test
			Technique		
1	A. Baradeswar A.	Speed: 0.6 to 1.0	Liquid casting	Wear: .0023 to .0034	Ultimate Strength :
	Baradeswar an	meter/sec, Load: 20 to 60		mm3/m	215 to 240 MPa,
	& A. Elaya Peru	Ν			Hardness: 115 to 134
	ma [2021] [39]				MPa, Flexural
					Strength : 330 to 440
					MPa
2	Sachi n Vijay	Sliding Distance:0 to	Ultrasonic	Microstructural	Compressive Strain:
	Muley et al.	3500, Load: 500 to	Vibrations	Examination	0 to 0.23,
	[2021][43]	1500g, Sliding Speed: 1		Wear: .0026	Compressive
		m/sec		to .014mm ³ /m	Strength: 0 to 410
					MPa
3	Yuhai et al.	Heat Treatment, Sliding	Liquid casting	Coefficient of	Hardness : 108 to
	[2021][40]	time:30 to 120 min Load:		friction: 0.55 to 0.59,	135 HB
		10 to 40 N Sliding		Mass loss: 1.6 to	
		velocity: 60 to 240m		16.5 miligram	
4	Gheorghe Iacob et	Pow der Metallurgy	Powder	Morphological	Hardness: 150- 390
	al [2021] [41]		Metallurgy	changes	HV

Table1: Analysis of the Characteristics of Composites Based On Aluminium Alloy Matrix



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5	M. Lieblich et al.	load: 42 &140 N	Powder	Coefficient of	Hardness : 1.08-
	[2021][42]	Varying Mixing method	Metallurgy	friction: 0.18 to 0.73	1.47HV
				Vol. loss: 11 to 23	
				mm ³	
6	G. Elango &B.K.	Load: 30-50N Sliding	Casting	Wear: 0.014 to	-
	Raghu nath	Distance:0- 500m	0	0.04 mm ³ /m 0.46 to	
	[2020]			0.7 Microstructural	
	[46]			Examination	
7	Faiz Ahmad et al.	Load: 0-100N Sliding	Casting	Coefficient of	-
	[2020] [44]	Distance:0- 1000m	8	friction: 0.16- 0.32.	
				Wt. loss: 0.0043 to	
				0.103gm	
				Microstructural	
				Examination	
8	K S Alhawari et	Sliding Distance:0-	Semi solid	Microstructural	Hardness: 62-
0	al [2020.1.[45]	10Km	processing	Examination Wear	74BHN
	un [2020] [10]	Torun	technique & Stir	0.000028 to 0.00019	
			Casting	mm^{3}/m	
9	Kumar et al	Load: 10-30 N Sliding	Casting	Weight loss: 32 to	_
Í	[2020] [48]	Distance 1000 - 2000m	Custing	69mg Coefficient of	
		Distance.1000 - 2000m		friction: 0.41 to 0.5	
				Microstructural	
				Examination	
				Examination	
10	I Gandr a et al	Sliding Distance · 0-	Friction	Coefficient of	Hardness: 65-108
10	[2020] [47]	300m	surfacing	friction: 0.25- 0.56	HV
		50011	surracing	Wear: 0.042-	11 (
				0.076mg/m Micro	
				structural	
				Examination	
11	P. Ravindran et al.	Load: 0 to 30N. Speed: 0	Powder	Coefficient of	Hardness : 52-63
	[2020][51]	to 3.0 m/s Sliding	metallurgy	friction: 0.02 to 0.3.	BHN
		Distance : 500 to 3000m		Weight loss: 0.0012	
				to 0.021 gm.	
				8	
12	Ravinder Kumar	Load: 20 to 60N Speed:	Stir casting	Microstructural	-
	and Suresh	2 to 6m/sec Sliding	C	Examination,	
	Dhiman [2020]	Distance: 1000 to 5000m		Wear:.0 00042	
	[49]			to .000465 mm ³ /Nm	
13	Heguo Zhu et al.	Load: 20-50 N, Speed:	Powder	Coefficient of	Hardness: 60-
	[2019][54]	0.4 to 0.75 m/sec, Sliding	metallurgy	friction: 0.067 to	77.2HV Ultimate
		Distance: 0 to 200m		0.534,	Strength : 190-
				Wear: 0.000043 to	215Mpa
				0.00009 5gm/Nm	I.
14	C.A. Leon Patino	Load: 103N, Speed: 0.3	Directional	Microstructural	Hardness: 84- 290
	et al [2019] [50]	to0.9 m/sec, Sliding	Infiltration	Examination, Wear:	HV
		Distance : 0 to 2000m		0.00001 4	
				to .0076mm ³ /Nm	
15	F. Toptan et al.	Sliding Distance: 200	Squeeze Casting	Coefficient of	Hardness:
	[2019] [53]	400meter. Speed: 0.02	- queeze cusuing	friction: 0.48- 0.98	119- 135HV
	[2012][00]	0.03 m/sec. Load: 20		Wear: 0.00650-	
		40N		0.03650 mg/m	
				5.05050 mg m	

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III. CONCLUSION

There are stimulating openings for producing the demanded aluminium matrix composites having excellent property like high strength, low weight, less wear, satisfactory ductility. These composites synthesise by various technique. As discussed in this paper the Stair casting method is very useful for fabrication the various aluminium metal matrix composites because it gives uniformly distributed reinforcement particles in the aluminium metal matrix. Apart from this it was observed that the toughness and fatigue strength of a cooled slope cast aluminium alloys matrix alloy better than those made from aluminium metal Matrix composite employing the steering casting procedure. In the recent years powder metallurgy process for the fabrication of aluminium alloys matrix shows remarkable development because it shows more uniform dispersion this technology is very attractive because part formed by this technique need negligible finishing besides it shows financial advantage also. By friction surfacing deposition of composite layers is possible in the matrix based on aluminium. In order to achieve pre-defined gradient, the enabling the multi layering process to adapting coating of the composition. To attain sound bonding between layers with exception of Ages the multilayer composite coating is very useful.

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