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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]. Al-alloy 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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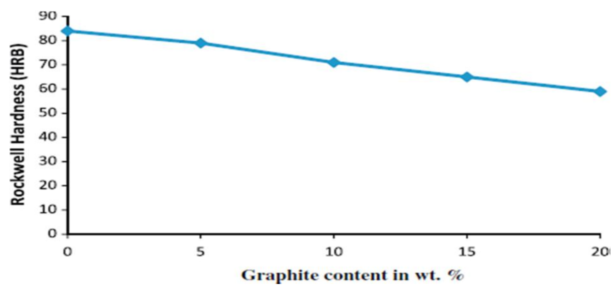
Baradeswaran et al. [2021] studied the effect (wear behaviour) of Graphite reinforcement on the aluminium 7075 / Al_2O_3/5wt. % graphite hybrid composite. Liquid metallurgy route is used to fabricate the composite. Solid lubricating material and ceramic particles were used with aluminium alloy matrix 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+Al_2O_3+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 B_4C 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 Al_2O_3 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].



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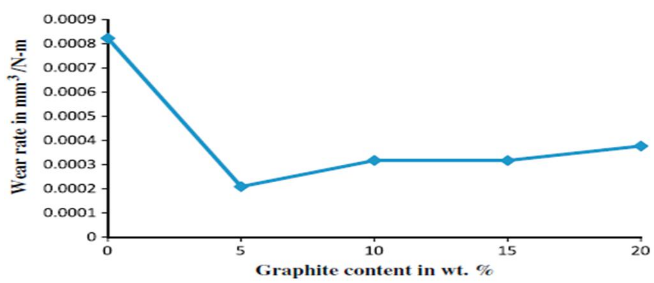

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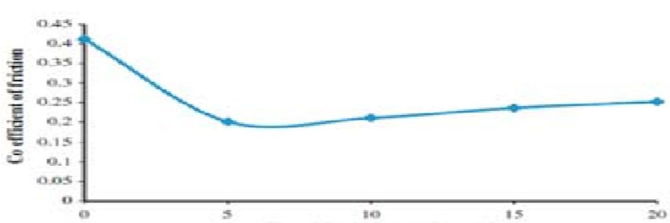

(c)

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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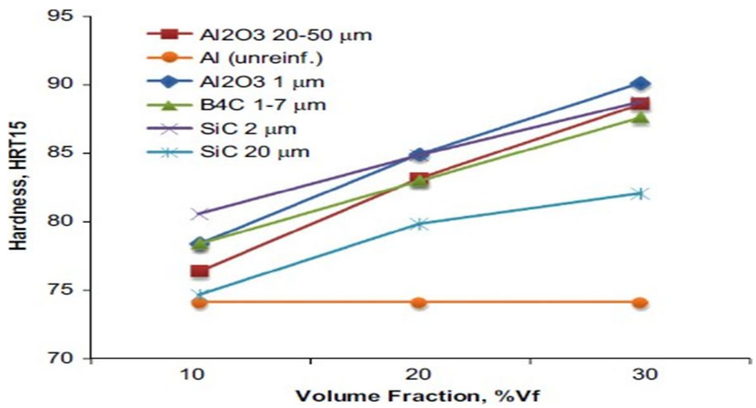

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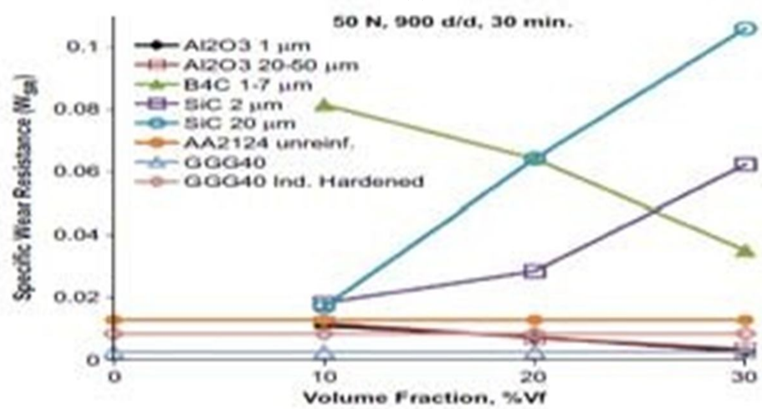

(b)

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

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

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

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

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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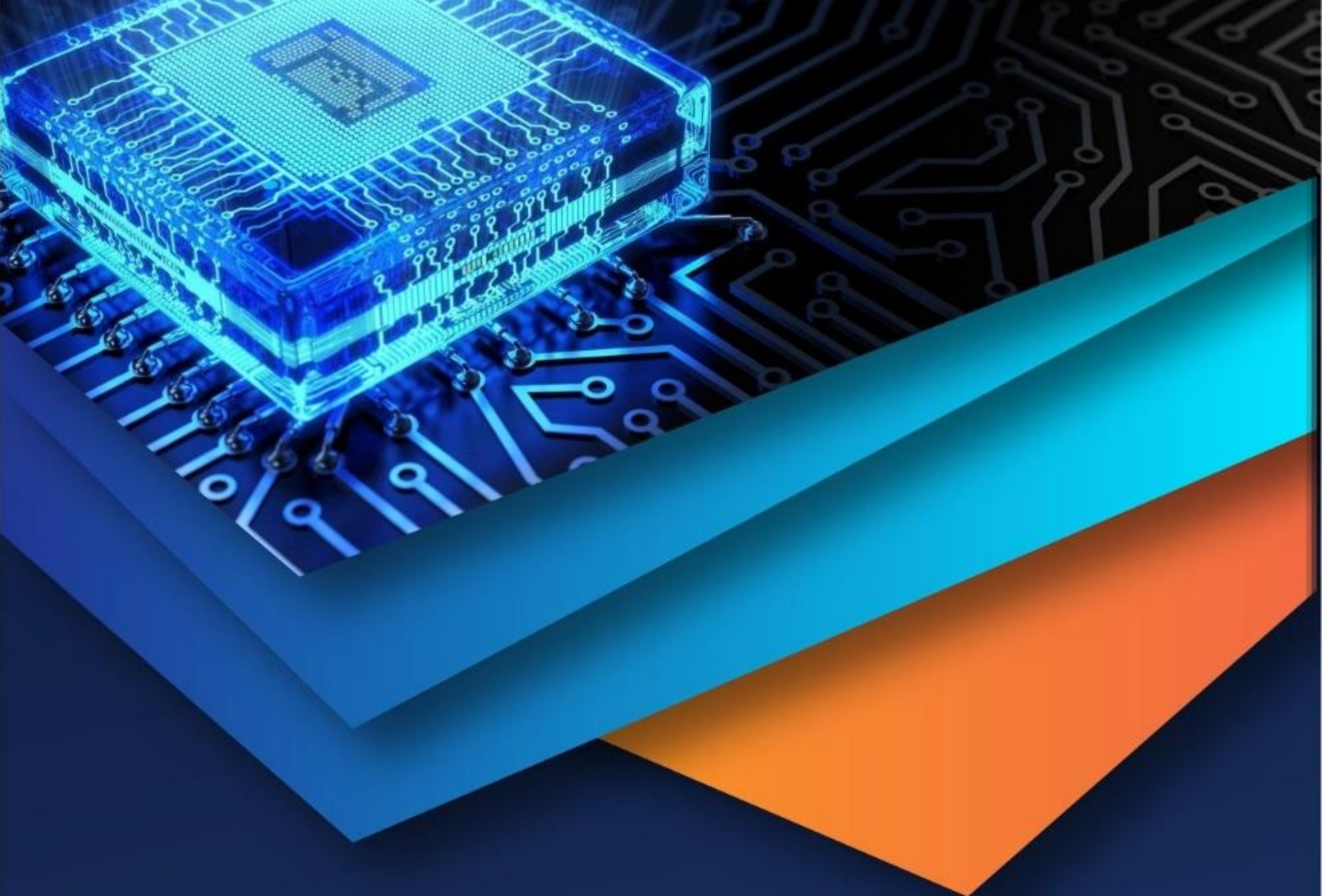

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