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"A REVIEW ON TRIBOLOGICAL CHARACTERIZATION OF DIFFERENT METAL MATRIX COMPOSITES"

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ABSTRACT

Aluminum metal matrix composites (AMCs) have excellent physical and mechanical qualities, making them potential materials for a variety of applications. In comparison to standard construction materials, the expansion of fortifications into the metallic framework improves the hardness, explicit quality, wear, creep, and weariness features. The influence of expansion on various fortifications made of aluminium is depicted in a diagram in this research, along with positive and negative effects. This paper discusses actual problems including fibre-framework holding, agglomerating processes, and problems related to particle dispersion. It is also thoroughly described how different forms of support for AMCs affect their mechanical characteristics, such as rigidity, strain, hardness, wear, and exhaustion. This paper also includes actual applications of various AMCs..

Key Words: *Aluminium metal matrix composite. Reinforcement, Aluminium, Silicon, Zirconia.*

I. INTRODUCTION

MMC (Metal matrix composites) are metals rein-forced with other metal, ceramic or organic com-pounds. They are made by dispersing the reinforcements in the metal matrix. Reinforcements are usually done to improve the properties of the base metal like strength, stiffness, conductivity, etc. Aluminium and its alloys have attracted most attention as base metal in metal matrix composites. Aluminium MMCs are widely used in aircraft, aerospace, auto-mobiles and various other fields. The reinforcements should be stable in the given working temperature and non-reactive too. The most commonly used reinforcements are Silicon Carbide (SiC) and Aluminium Oxide (Al_2O_3). SiC reinforcement in-creases the tensile strength, hardness, density and wear resistance of Al and its alloys. The particle distribution plays a very vital role in the properties of the Al MMC and is improved by intensive shearing. Al_2O_3 reinforcement has good compressive strength and wear resistance. Fibres are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Zircon is usually used as hybrid reinforcement. It increases the wear resistance significantly. In the last decade, the use of fly ash reinforcements has been increased due to their low cost and availability as waste by-product in thermal power plants. It in-creases the electromagnetic shielding effect of the Al MMC. Based on the stated potential benefits of MMC this paper examine the various factors like (a) effect of various reinforcement (b) mechanical behaviour like strength, wear ,fatigue behaviour, etc. (c) processing methodology and its effects.(d) application of the speciality AMC were discussed.

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II. LITERATURE REVIEW

1. ALUMINIUM OXIDE REINFORCED AMC

Park et al. studied Al2O3's impact on aluminium was examined volume fractions ranging from 5–30%, and they discovered that as the volume fraction of Al2O3 increased, the MMC's fracture toughness declined. This is brought on by a reduction in the distance between nucleated micro voids. The high cycle fatigue behaviour of 6061 Al-Mg-Si alloy reinforced Al2O3 microspheres with different volume fractions ranging between 5% and 30% was examined by Park et al. discovered that the composite produced using powder metallurgy had a higher fatigue strength than the composite processed using liquid metallurgy and an unreinforced alloy.

Kok et al investigated The ideal conditions for the production process were determined pouring temperature of 700 C, a preheated mould temperature of 550 C, a stirring speed of 900 rev/min, a particle addition rate of 5 g/min, a stirring time of min, and an applied pressure of 6 MPa. Kok also studied the mechanical properties of the Al2O3 particle reinforced 2024 Al alloy composites and created them by vortex method. Applying pressure increased the wettability and the link between Al alloy/Al2O3 particles, but it also reduced porosity. Using the electromagnetic stir casting process, Abhishek Kumar et al. experimentally investigated the characteristics of A359/Al2O3 MMC. They discovered that electromagnetic stirring action produces MMC with reduced grain size and strong par-ticulate matrix interface bonding, increasing the material's hardness and tensile strength. The heat deformation and wear resistance of powder metallurgy aluminium metal matrix composites were examined by Abouelmagd. Al2O3 and Al4C3 were discovered to boost hardness and compressive strength. Al4C3 was added to the MMC, which increased its wear resistance. To investigate the impact of cutting settings and particle characteristics on the micro-hardness variations on the machined Al2O3 particulate reinforced AMC, Kannan and Kishawy performed orthogonal cutting tests. The micro-hardness was discovered to be increased close to the fabricated surface layer. For low volume fraction and coarse particles, micro-hardness fluctuations were more pronounced.

2. SILICON CARBIDE REINFORCED AMC

Tamer Ozben et al. were examined The mechanical and machinability characteristics of SiC particle reinforced Al-MMC. Tensile strength, hardness, and density of the Al MMC material all rose with the reinforcement ratio, while impact toughness decreased. Under various temperature circumstances.

Sedat Ozden et al. looked into the impact behaviour of Al and SiC particles reinforced with AMC. Composites' impact behaviour was impacted by particle clustering, particle cracking, and brittle matrix-reinforcement bonding. The test temperature had just a minimal impact on how each material responded to impacts. In a study on high cycle fatigue.

Srivatsan et al. investigated the fracture behaviour of metal matrix composites made of 7034/SiC/15p-UA and 7034/SiC/15p-PA. As temperature increased, the modulus, strength, and ductility of the two composite microstructures all decreased. The under-aged microstructure showed higher degradation in cyclic fatigue life than the peak-aged microstructure. A higher fatigue strength was also obtained for the particular ageing state by increasing the load ratio.

Maik Thunemann et al. investigated the properties of performs. Polymethylsiloxane (PMS) was used as a binder. The preforms were stable enough with a polymer composition of 1.25 weight percentage to allow for composite processing. Thus, it is demonstrated that the PMS-derived binder gives the SiC preforms the necessary strength without degrading the mechanical properties of the final Al/SiC composites.

Sujan et al. studied about The performance of stir-cast Al2O3 and SiC reinforced metal matrix composite material was The outcome demonstrated that composite materials have better physical and mechanical characteristics, including a low coefficient of thermal expansion as low as 4.6x10-6/C, a high ultimate tensile strength as high as 23.68%, and high impact strength and hardness. The composite materials have the potential to be used in lightweight automotive components. In experiments, it was discovered that Al-SiC reinforcing particles caused the composite to wear down more slowly than Al-Al2O3 composites.

Zhang Peng et al. studied The effects of particle clustering on the flow behaviour of SiC particle reinforced Al MMCs looked into the findings, during tensile deformation, particle clustering has a far bigger impact on the matrix's mechanical reaction than it does on its elastic response. It also has a significant impact on the matrix's plastic deformation. When compared to particle random distribution, the particle clustering microstructure will fracture more frequently.

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The impact of stirring duration and speed on the dispersion of particles in SiC AMC was examined by **Balasivanandha Prabhuet et al.** in their study published in 2012 [12]. In the work, 10% SiC was synthesised from high silicon aluminium at various stir-ring speeds and stirring periods. The investigation showed that when the stirring speed and time were reduced, the particle clustering was more pronounced in specific areas. By raising these parameters, the distribution improved and also had an impact on the composite's hardness. At 600 rpm and 10 minutes of stirring, uniform hardness values were obtained.

Tzamtzis et al. recommended using a new Rheoprocess to process Al/SiC particulate MMCs under intense shearing. The ductile matrix is frequently produced by current processing techniques, such as conventional stir casting, and as a result, these composites have very low ductility. The Rheo-process, on the other hand, enabled the application of sufficient shear stress (s) on particulate clusters embedded in liquid metal to overcome the average cohesive force or the tensile strength of the cluster, which significantly improved the distribution of the reinforcement in the matrix.

An alternative method of compo forging Al-Si Metal Matrix Composites reinforced with SiC was proposed by **Valencia Garcia et al.** The mechanical resistance to elongation was increased by this preparation technique. As fewer production stages, as well as less time and energy are consumed, this process shows to be more cost-effective. From the perspective of productivity.

Narayana Murty et al. suggested that bulk working activities should be performed in a high strain rate region with high values of mass and efficiency, whereas secondary metal working operations should be performed in a lower strain rate region.

The effects impacting surface roughness on the machining of Al/SiC particulate composites were evaluated by **Palani Kumar and Karthikeyan**. Using the response graph, response table, normal probability plot, interaction graphs, and analysis of variance (ANOVA) approach, the parameters such as feed rate, cutting speed, and percentage volume fraction of SiC were tuned to achieve the lowest surface roughness. The factor that has the biggest impact on surface roughness is feed rate, which is followed by cutting speed and the volume fraction of SiC. For rough and medium turning processes, low cutting speed with high feed rate and depth of cut are advised. High cutting speed and low feed rate produce improved surface finish when using coated carbide cutting tools.

Natarajan investigated the wear behaviour of A356/25SiC MMC with the typical grey Cast iron sliding against vehicle friction material. It has been discovered that the composite has a higher wear resistance than typical grey cast iron, making it a perfect material for brake drums. The volume fraction of SiC and its size in the composite are the main variables determining tool life.

3. BORON CARBIDE REINFORCED AMC

Trimodal aluminium metal matrix composites and the variables influencing their strength were studied by **Bo Yao et al**. The test result demonstrates that characteristics such as nitrogen concentration and distribution, interfaces between different constituents, high dislocation densities in both NC-Al and CG-Al domains, nanoscale dispersoids of Al_2O_3, crystalline and amorphous AlN, and Al_4C_3 all contribute to increased strength. Cryomilled aluminium alloy and boron carbide nano-composite plates were made in three different ways: hot isostatic pressing (HIP) followed by high strain rate forging (HSRF), hot isostatic pressing (HIP) followed by two-step quasi-isostatic forging (QIF), and three-step QIF.

According to **Vogt et al**. The test findings revealed that compared to the QIF plates, which had identical mechanical properties, the HIP/HSRF plate had more strength but poorer ductility. The HIP/HSRF plate's increased strength and decreased ductility are ascribed to the prevention of dynamic recrystallization that occurred during the high strain rate forging process.

Mahesh Babu et al investigation of the Taguchi method's surface quality attributes on hybrid aluminium-B4C-SiC metal matrix composites. The cutting speed was shown to be the second most crucial element after feed rate. Additionally, it was determined that the feed rate had little to no impact on surface quality.

The impact of using the conventional investment casting technique in aluminium metal matrix composites was examined by **Barbara Previtali et al.** Comparing aluminium alloy reinforced with SiC and B4C, the investigations revealed that SiC reinforced MMC has a greater wear resistance than B4C reinforced MMC.

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4. FIBRE REINFORCED AMC

According to **Sayman et al** .study of the elasto plastic stress analysis of aluminium and stainless steel fibre, strong bonding between the matrix and fibre was seen under 30 MPa pressure and at a temperature of 600 C, and the load carrying capacity of the laminated plate also increased. According to Cesim Atas and Onur Sayman yielding for steel fibre reinforced aluminium MMC plates starts near the laminated plates' edges. They discovered that the plate's corner is not where the yielding takes place. In a total strain controlled mode.

Ding et al. examined the low cycle fatigue behaviour of pure aluminium reinforced with 20% Al2O3 fibre. They discovered that, across a wide range of strain amplitudes and test temperatures, the projected fatigue lives match the observed fatigue lives. However, only at high levels of total and cyclic plastic strain do the anticipated fatigue lives best match the observed fatigue lives. The behaviour of the unreinforced 6061 aluminium alloy and the 6061Al alloy MMC was studied by Ding et al. They discovered that the inclusion of high-strength Al2O3 fibres in the matrix of the 6061 aluminium alloy will not only strengthen the alloy's microstructure but will also channel crack tip deformation into the regions of the matrix between the fibres, restricting the matrix's capacity for plastic deformation and lowering fatigue ductility.

The flow stress increases with strain rate but decreases with temperature, according to research by **Woei-Shyan Lee et al.** on the impact of strain rate on the characteristics and fracture behaviour of laminated Carbon fibre reinforced 7075-T6 aluminium alloy. With an increase in strain and temperature, the rate of work hardening reduces. For all temperatures, increasing strain rates were associated with a higher density of aluminium debris and fibre fracture. According to Gudena and Hall who examined the high strain rate compressive deformation behaviour of a continuous Al2O3 fibre reinforced Al MMC tested in the longitudinal and transverse directions, the composite exhibits strain rates similar to those of monolithic alloy in the transverse direction. In their study of electroless nickel coated fibre reinforced aluminium matrix composites, Rams et al. discovered that the composite's wettability rises. The Ni-Al-P transitory intermetallic layer that forms as a result of heating is what improves wettability and minimises damage to fibre.

Shi et al investigation into the shape and surface properties of diamond fiber-reinforced aluminium matrix composites. High thermal conductivity and a small thermal expansion coefficient are features of the composite. The diamond fibres and the aluminium matrix successfully bind thanks to the pressure-free metal infiltration technique.

5. ZIRCON REINFORCED AMC

The characteristics of Al6063 MMC reinforced with Zircon Sand and Alu-mina with four distinct volume fractions of Zircon sand and Alumina with changing volume fractions of (0+8%), (2+6%), (4+4%), (6+2%), and (8+0)% were compared by **Jenix Rina et al.** in their study. The composites have increased hardness and tensile strength when (4+4)% is present. In their comparative study of the abrasive wear of an Al-Cu alloy with alumina and zircon sand particles.

Sanjeev Das et al. discovered that the alloy's wear resistance dramatically rises when alumina and zircon particles are added. However, due to their greater particle matrix bonding, zircon reinforced composites outperformed alumina reinforced composite in terms of wear resistance.

III. PROBLEM DEFINITION

Wear analysis of aluminium metal matrix composite has been performed along with different metals and ceramics in the matrix. Graphene is employed in the metal matrix of aluminium to analyse the reduction in wear and coefficient of friction of the synthesized samples.

IV. PROPOSED OBJECTIVE

1. To study the uniform distribution of alumina nano particles in the aluminium metal matrix.
2. To study the uniform distribution of graphene particles in the aluminium metal matrix.
3. To study the hardness behaviour of alumina and graphene synthesized composite as compared to aluminum matrix composites.
4. To study study the wear resistance behaviour of alumina and graphene synthesized composites.

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V. Expected Outcomes

1. Uniform distribution of alumina nano particles in the matrix will be achieved.
2. Uniform distribution of graphene in the matrix will be achieved.
3. Higher hardness as compared to aluminum matrix composites. Will be achieved in composite synthesized with alumina and graphene.
4. Higher wear resistance will be achieved in the alumina and graphene synthesized composites.

VI. Conclusion

To increase the engineering use of AMCs, a number of challenges must be overcome, including processing methodology, the influence of reinforcement, the effect of reinforcement on mechanical properties, and its related applications. The following summarises the main conclusions drawn from the earlier research:

- SiC reinforced Al MMCs outperform Al2O3 reinforced MMCs in terms of wear resistance.
- SiC reinforced Al MMCs have a high wear resistance, making them ideal for brake drums, however they cannot be utilised for brake linings because doing so will harm the brake drum.
- It has been discovered that the Al MMC's fracture toughness diminishes as the volume percentage of Al2O3 increases.
- The ideal conditions for manufacturing Al2O3 reinforced Al MMC were 700^0C for pouring, 550^0 C for preheating the mould, 900 rev/min for stirring, 5 g/min for adding particles, 5 min for stirring, and 6 MPa for pressure being applied.
- SiC reinforced Al MMC has a greater wear resistance than B4C reinforced MMC.
- High thermal conductivity and a low thermal expansion coefficient can be found in Al MMCs reinforced with diamond fibre.
- Zirconia reinforcing improves the compressive strength and wear resistance of Al MMCs.

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