Journal of Engineering and Technology for Industrial Applications

ISSN ONLINE: 2447-0228

ITEGAM-JETIA

Manaus, v.11 n.54, p. 163-171. July/August., 2025.
DOI: https://doi.org/10.5935/jetia. v11i54.1706

RESEARCH ARTICLE OPEN ACCESS

# LITERATURE REVIEW ON MECHANICAL PROPERTIES AND BEHAVIOR OF ALUMINUM METAL MATRIX COMPOSITE MATERIAL WITH DIFFERENT PROCESSES

**Jignesh G. Parmar[1], Mehul G. Mehta[2], Nital P. Nirmal[3]**

[1,2,3]Gujarat Technological University, India

[1]http://orcid.org/0000-0002-8533-8304, [2]http://orcid.org/0009-0002-2219-0848, [1]http://orcid.org/0000-0002-8657-4253

E-mail: jiger.mechanical1@gmail.com, mgmehta@mech.ssgec.ac.in, nital.nirmal@gmail.com

**ARTICLE INFO**

***Article History***
Received: March 13, 2025
Revised: April 20, 2025
Accepted: June 15, 2025
Published: August 31, 2025

***Keywords:***
Composite material,
Metal matrix,
Reinforcement,
Mechanical properties,
Processing technique.

**ABSTRACT**

This literature review studies the development, characterization, and applications of Aluminum Metal Matrix Composites (AMMCs). Focusing on different types of reinforcement materials with their processing techniques, mechanical properties, and performance in various applications. Aluminum Metal Matrix Composites (AMMCs) have garnered significant attention due to their superior mechanical properties, including lightweight, high strength, corrosion resistance, and excellent wear properties. These composites consist of aluminum alloys as the matrix material, reinforced with various ceramic particles. Reinforcements such as silicon carbide (SiC), iron oxide ($Fe_3O_4$), boron carbide (B4C), alumina ($Al_2O_3$), and graphite have been extensively studied to enhance the properties of aluminum alloys.



## I. INTRODUCTION

Composite materials play an important role in human life for many years of their capability to infrastructure and continue to enable developments in modern technology [1]. In base materials, many issues have been generated including with corrosion, wear resistance, weight, etc. A composite material is a prepared artificially with combination of two or more materials. The different parts are separated by specific boundaries [2]. The various advantages of the use of composites materials such as, increase the stiffness, strength, toughness and other mechanical and electrical properties.

The composites materials reveal better uses in industries such as automobile, aerospace, sports, defense, medical etc.. Many problems have been resolved due to the improved chemical, mechanical, physical, and thermal features of composite materials. Two phases of composites have been used such as reinforcement and matrix [3]. This literature review summarizes the work of several researchers on the fabrication, mechanical properties, and applications of Metal matrix composites (MMCs), focusing on different reinforcement materials, fabrication techniques, and performance evaluation. Aluminum matrix. Composites (AMCs) have gained considerable attention in various engineering applications due to their enhanced mechanical properties. Reinforcements like silicon carbide (SiC), alumina ($Al_2O_3$), boron carbide (B4C), and others have been employed to improve the mechanical and corrosion properties of aluminum alloys. This paper studies on the effects of different reinforcements and processing techniques on the properties of AMCs.

## II. METHODOLOGY

The literature survey was carried out as a part for development of this research paper. In this paper studied of different manufacturing processes, properties and behavior of aluminum metal matrix composites. The research work done by researchers on aluminum metal matrix composite materials. This literature review gives a strong establishment for the current study and may reveal its importance for future investigation also. The research depend on references from various national and international journals, books, articles and websites.

## III. LITERATURE REVIEW

Srivatsan et al. (1991) explored processing methods for aluminum-based particulate MMCs, emphasizing the influence of matrix composition and reinforcement characteristics on the material's microstructure. This study helped clarify the role of processing techniques in achieving desired properties in engineered MMCs [4]. Doel & Bowen et al. (1993) studied particulate-reinforced aluminum MMCs using SiC as reinforcement. Their work compared the mechanical properties of composites with coarse and fine SiC particles, finding that finer particulates improved ductility, while coarser particles provided better toughness [5]. Pradeep K. Rohatgi (1993) reviewed the global surge in metal-matrix composite (MMC) research, particularly focusing on cast metal-matrix particulate composites. The study emphasized that MMCs can offer specific technical properties that traditional materials cannot achieve, provided that the relative quantities and distributions of the components are managed carefully during manufacturing. Various manufacturing techniques were examined, revealing that in alloys like Al-Si, the eutectic and primary silicon tend to concentrate on the surface of the particle or fiber. Two critical factors generating interest in MMCs include heterogeneous nucleation of the primary phase on reinforcing particles (e.g., graphite, SiC) and particle entrapment during solidification [6]. Surappa (2003) explored the versatility of aluminum matrix composites (AMCs) and the role of ceramic reinforcements (whiskers, particles, fibers) in enhancing their mechanical, thermal, and tribological properties.

The study emphasized the adaptability of AMCs to meet industrial demands by selecting appropriate matrix-reinforcement combinations. AMCs have been studied for over three decades, with a significant body of knowledge accumulated regarding their properties and applications [7]. Natarajan et al. (2006) studied the wear behavior of LM25/SiC composites in brake shoe applications. The results indicated that the AMC showed superior wear resistance compared to grey cast iron, and the coefficient of friction increased with sliding velocity [8]. Montoya Davila et al. (2007) explored the impact of particle size distribution on the hardness and fracture toughness of Al/SiCp composites. Their findings suggested that both microhardness and fracture toughness behaved parabolically with an increase in particle-size distribution [9]. Hajjari et al. (2008) examined the impact of squeeze casting on the microstructure and tensile properties of 2024 aluminum alloy. The results showed that squeeze casting refined the microstructure, reduced porosity, and increased the ultimate tensile strength due to faster cooling and increased squeeze pressure [10]. Cheng et al. (2008) studied the preparation and deformation behavior of silicon carbide (SiC)-reinforced aluminum 6066 composites fabricated by powder metallurgy. The SiC particles were evenly distributed, and failure modes such as particle cracking and ductile tearing at the interface were observed, with the deformation behavior heavily dependent on the matrix alloy [11]. Tan & Mohamad (2009) focused on the artificial aging of Al6061-T6, determining optimal temperature and time for maximum hardness [12]. Wahab et al. (2009) developed aluminum metal matrix composites (AMMCs) reinforced with aluminum nitride (AIN) using a permanent stainless-steel mold and a graphite crucible. They observed that AIN particles were well distributed around primary silicon grains and other structures. Hardness tests showed an increase in hardness, indicating that AIN reinforcement significantly improved the material properties [13]. E. Bayraktar et al. (2010) developed an aluminum matrix composite reinforced with iron oxide ($Fe_3O_4$) to enhance conductivity and magnetic permeability.

They employed microwave sintering to produce a well-distributed reinforcement within the aluminum matrix, achieving greater density compared to conventional sintering [14]. Ramesh et al. (2010) noted the combined effect of adhesion, abrasion, and delamination in increasing wear rates at higher loads [15]. Ibrahim Sahin et al. (2010) analyzed the mechanical properties and microstructures of SiCp-reinforced $AlSi_7Mg_2$ matrix composites, which were produced by squeeze and gravity casting methods and T6 heat-treated. They found that squeeze casting led to more refined microstructures and improved mechanical properties, while gravity casting produced non-homogeneous distributions due to slow cooling [16]. Katica Milos et al. (2011) investigated the incorporation of $Al_2O_3$ ceramic particles into aluminum using powder metallurgy. They found that while low $Al_2O_3$ concentrations resulted in uniform particle distribution, higher concentrations led to particle agglomeration, which reduced hardness [17]. S. M. Suresh et al. (2011) investigated LM25 aluminum alloy MMCs reinforced with micro and nano $Al_2O_3$ particles.

Their findings suggested that stir casting is a viable method for manufacturing nanoparticle-reinforced MMCs, with nanocomposites exhibiting slightly better tensile strength and hardness than their micro $Al_2O_3$ counterparts [18]. Neelima Devi et al. (2011) explored the mechanical and corrosion behavior of aluminum-silicon carbide (SiC) composites. They found that the composite material exhibited a significantly better weight-to-strength ratio (almost three times greater than mild steel) and was lighter than pure aluminum. The maximum tensile strength was achieved at a 15% SiC ratio, demonstrating that the aluminum-SiC composite is both stronger and lighter than pure aluminum [19]. A. Chennakesava Reddy (2011) analyzed the mechanical behavior of Al/Sic Metal Matrix Composites using Taguchi's methods. His study showed that the volume fraction of SiC and the type of aluminum alloy used (Al 6061, Al 6063, and Al 7072) significantly affected the yield strength, ultimate tensile strength, and ductility of the composites [20]. Anoop Kumar Tuli et al. (2021) explored the effects of thixocasting and gravity casting on LM25-10wt% SiC composites. Thixocasting enhanced the composite's mechanical properties, showing improved tensile, compressive, and flexural strengths when compared to gravity casting. SEM analysis revealed particle shearing as the primary fracture mechanism in this cast samples [21].

Nrip Jite et al. (2011) compared the porosity and density of A384.1 MMCs reinforced with SiC particles. They found that changes in particle size and reinforcement percentage significantly affected the density and porosity of the composites. Specifically, the highest density was observed at 2490 $gm/cm^3$ for a SiC content of 0.08, with a particle size of 0.106 m, and the highest porosity was recorded at 3.25% for a SiC content of 0.10 [22]. R. Kartigeyan et al. (2012) studied Al 7075 alloy reinforced with short basalt fibers, finding that the composite exhibited significant improvements in hardness, yield strength, and ultimate tensile strength, particularly with 6% basalt fiber [23]. G. G. Sozhamannan et al. (2012) studied the impact of processing temperatures and holding times on the mechanical properties and particle distribution in Al-SiCp MMCs. They observed that processing at higher temperatures and longer holding times resulted in improved strength, although excessive holding time led to reduced ultimate strength [24]. Ali Mazahery et al. (2012) studied the effect of SiC nanoparticles on the mechanical properties of A356 alloys, finding that the addition of SiC nanoparticles significantly enhanced hardness, yield strength, and ultimate tensile strength. The composites exhibited small porosity and a uniform distribution of SiC nanoparticles [25]. Mohsen Ostad Shabani et al. (2012) focused on the A356 matrix reinforced with B4C particulates. They found that B4C particles were evenly dispersed along dendritic branches, and the composites showed enhanced mechanical properties, such as higher strain hardening and ultimate tensile strength compared to unreinforced alloys. They also employed an artificial neural network (ANN) and finite element method to model the mechanical properties [26]. Pargunde et al. (2013) employed a stir casting technique to fabricate aluminum-based silicon carbide (AlSiC) composites, highlighting the two-step mixing process's role in enhancing composite properties such as hardness and impact strength with increasing SiC content [27].

Gurvishal Singh et al. (2013) explored the use of red mud, SiC, and $Al_2O_3$ as reinforcements in aluminum MMCs. Their findings highlighted that red mud could replace more expensive reinforcements like SiC and $Al_2O_3$, providing a cost-effective alternative without compromising wear resistance and hardness [28]. Tahamtan et al. (2013) fabricated Al206/5vol. % $Al_2O_3$ composites through an injection process in which reinforcing particles were added to molten Al. Their study showed that the inclusion of $Al_2O_3$ particles resulted in improved distribution and incorporation of particles, enhancing the tensile properties of the composite [29]. Sharanabasappa R. Patil (2013) examined the mechanical properties of LM25 composites reinforced with fly ash and alumina. The study showed that increasing the percentage of $Al_2O_3$ enhanced the hardness of the composites, though it reduced elongation and ductility, highlighting a trade-off between hardness and ductility [30]. Bhaskar Chandra Kandpal et al. (2014) reviewed the various technologies for producing metal matrix composites (MMCs). These include liquid and solid-state techniques such as stir casting, powder metallurgy, and metal injection molding. The review emphasized the importance of cost-effectiveness, productivity, and the development of new processes like mechanical alloying and continuous binder powder coating to meet industrial requirements for MMCs [31]. Akhilesh Jayakumar (2014) examined the properties of LM25-based metal matrix composites, where SiC served as reinforcement. Composites were processed via centrifugal casting, and microstructural studies showed significant improvements in mechanical properties with SiC reinforcement [32]. L. Bolzoni et al. (2014) focused on grain refinement of Al-Si alloys using Nb–B inoculation.

Their study demonstrated that the addition of Nb–B inoculants effectively refined the primary α-Al dendrites in alloys like LM24 and LM25, reducing the grain size significantly. This refinement was particularly beneficial for casting processes that depend on cooling rates [33]. S. Kumar et al. (2015) applied grey relational analysis to optimize machining parameters, such as peak current and pulse on time, in wire electrical discharge machining (WEDM) of aluminum-based composites. Their study showed that reinforcement particles increased surface roughness, with longer pulse durations exacerbating this effect [34]. Mikhail Tashkinov (2015) developed a statistical technique to simulate the phase-level elastic fields of multiphase composites with SiC reinforcement. His study explored the microstructural behavior of TiC+SiC and Al+SiC metal matrix composites (MMCs). He analyzed how variations in microstructure influenced stress-strain fields, demonstrating the role of microstructural characteristics in affecting the mechanical properties of MMCs [35]. Svetlana Boshnakova et al. (2015) focused on stainless steel-based MMCs reinforced with silica and titanium, targeting high wear-resistant applications. The study explored microhardness, wear resistance, and roughness of MMCs, revealing improvements in wear resistance and hardness compared to the base steel. This work highlights the potential of TiC and SiC as reinforcement materials for wear-resistant composites [36].

Gyanendra Singh et al. (2015) studied the use of different metals (Mg, Zn) in aluminum matrix composites to produce high-strength, lightweight materials. The combination of these metals with $Al_2O_3$ reinforcement showed improvements in hardness, tensile strength, and impact strength. The study also highlighted the cost-effective nature of traditional casting processes in manufacturing such composites [37]. Biswajit Das et al. (2015) fabricated an in-situ multi-component reinforced aluminum copper alloy-based metal matrix composite using flux-assisted synthesis (FAS) and investigated its machining properties. The study revealed that cutting speed and depth of cut significantly influenced cutting force, and the predicted values for surface roughness and cutting force were in close agreement with experimental results, suggesting the effectiveness of regression analysis for optimization [38]. S. A. Mohan Krishna et al. (2015) highlighted the benefits of hybrid MMCs, including enhanced thermal conductivity and lower thermal expansion coefficients. They also discussed the potential for using Al/SiC/Graphite hybrid composites in aerospace applications [39]. Vishnu Prasad K et al. (2015) examined the effect of stirring speed during the stir casting process, noting that higher mold rotation speeds improved mechanical and tribological properties, reducing volume loss and enhancing wear resistance [40]. V. Vembu et al. (2015) utilized response surface methodology to optimize heat treatment for 8011 Al/15% SiCp metal matrix composites, improving tensile strength and ductility. They observed that solutionizing time had the most significant impact on tensile strength, with a peak increase in tensile strength under peak-aged conditions [41]. M.J. Shen et al. (2015) investigated the microstructure and tensile properties of AZ31B magnesium matrix composites reinforced with SiC particles.

Their findings indicated that SiC reinforcement refined the grain structure of the magnesium matrix, leading to improved tensile strength and yield strength [42]. Radhika N. (2015) conducted an extensive study on LM25/SiC/ $Al_2O_3$ composites, fabricated using a liquid metallurgy technique. The composites were reinforced with varying amounts of SiC and $Al_2O_3$ (0 to 30 wt%). Tensile and hardness tests showed an increase in mechanical properties with higher reinforcement contents, particularly at 10 wt% of SiC and $Al_2O_3$. Wear tests using a pin-on-disc tribometer revealed that the wear rate decreased as the reinforcement percentage increased, and the coefficient of friction increased with the applied load [43]. Venkatesh et al. (2015) used powder metallurgy to fabricate Al/SiCp composites and observed an increase in density and hardness with rising sintering temperature [44]. Pardeep Sharma et al. (2015) explored the microstructure of Al6082 matrix composites reinforced with graphite (Gr) particles. Through a traditional stir casting method, they studied the effect of Gr content (ranging from 0% to 12%) on the microstructure of the composites. Scanning electron microscopy (SEM) and X-ray diffraction (XRD) analyses revealed that the microstructure of cast Al6082 consists of a dendritic aluminum network and a silicon-aluminum eutectic network. Increased Gr content led to non-uniform particle distribution and the formation of impurities, resulting in a decrease in the hardness of the composites [45]. Venkatachalam G et al. (2015) investigated the microstructure and mechanical properties of modified LM25 aluminum alloy reinforced with zirconium (Zr) particles. Microstructural analysis revealed a homogeneous distribution of Zr particles, with fewer voids and porosity. The mechanical properties, such as hardness and tensile strength, improved with increasing Zr content. The study also highlighted the importance of stirring parameters and particle soaking before adding to the matrix [46]. Sri

Priya R et al. (2016) developed aluminum 6061 composites for aerospace by reinforcing them with silicon carbide (SiC) and alumina ($Al_2O_3$). Their results indicated improved yield and ultimate tensile strength with higher reinforcement percentages, although elongation decreased [47]. Anthony Xavior M et al. (2016) focused on the machinability of hybrid aluminum-based MMCs, noting that reinforcement type and distribution influenced cutting forces, tool wear, and surface roughness during machining processes [48]. A. Arora et al. (2016) worked on the fabrication of aluminum-molybdenum (Al-Mo) composites using the friction stir process (FSP). Their findings showed a homogeneous dispersion of Mo particles in the Al matrix, resulting in a significant increase in Vickers microhardness, showcasing the effectiveness of FSP in improving mechanical properties [49].

Anil Kumar Bodukuri et al. (2016) prepared Al-SiC-B4C metal matrix composites using powder metallurgy. The addition of boron carbide (B4C) was found to significantly increase microhardness, with the composite showing uniform particle distribution. This work demonstrated the potential of sintering as a technique to enhance the properties of aluminum composites [50]. N. Venkat Kishore et al. (2016) studied A356/LM25 aluminum alloys reinforced with boron carbide (B4C), finding that the mechanical properties of the composites, including tensile strength and hardness, improved with increasing boron carbide content [51]. N. Radhika (2016) developed homogeneous and functionally graded LM25 aluminum composites by incorporating silicon nitride ($Si_3N_4$) particles through liquid metallurgy and centrifugal casting. The microstructure of the composites showed uniform dispersion of $Si_3N_4$ in the homogeneous composite, while the centrifugal casting led to particle segregation, with a particle-enriched outer surface and a depleted inner region. The functionally graded composite exhibited reduced wear rates, especially at low loads [52]. Siddanna Awarasang et al. (2016) investigated the microstructure and impact strength of LM25 aluminum alloy reinforced with steel wire. The results showed good bonding between the steel wire and the aluminum matrix.

The impact strength of the composite significantly improved, and the proper bonding was confirmed through optical microscopy, which showed no voids in the bonding areas [53]. S. Venkatesan et al. (2016) investigated the mechanical behavior of aluminum metal matrix composites (AMMCs) reinforced with graphene particles using the stir casting method. Their findings indicated that graphene reinforcement at various weight fractions (0.33%, 0.55%, 0.77%) altered the microstructure, with broken dendritic grains leading to improved properties such as tensile and hardness strength. The presence of eutectic Si particles in stir-cast samples was observed as globular, unlike in the base matrix [54]. Juhi Mishra et al. (2017) examined various fabrication methods for MMCs, addressing challenges in the wetting of reinforcing phases during casting. The review discussed liquid phase processes, solid-liquid processes, and other methods, highlighting the potential of MMCs in industries like automotive and aerospace, despite the high costs of production [55]. Girija Moona et al. (2017) provided a retrospective review of AMMCs, highlighting their increased hardness, toughness, and wear resistance compared to unreinforced aluminum. They discussed challenges such as machinability, high cost of nano-reinforcements, and difficulties in secondary processing, which hinder broader industrial applications [56]. Arvind Sankhla et al. (2017) compared the advantages of MMCs over polymer-based composites, citing superior strength, stiffness, and wear resistance. They advocated for powder metallurgy as an efficient technique for MMC production, particularly with reinforcements like silicon carbide and aluminum oxide [57].

Chowda Reddy et al. (2017) investigated the use of centrifugal casting for fabricating aluminum alloy MMCs with Al2O3 reinforcement. Their results showed that increasing mould rotation speed improved hardness and wear resistance, particularly at 1500 rpm, due to the better distribution of $Al_2O_3$ particles [58]. Dhanasekaran R et al. (2017) studied the hardness of A356 aluminum composites reinforced with SiC, graphite, and alumina. They found that increasing SiC content improved hardness, but excessive amounts led to a reduction, highlighting the importance of optimal reinforcement levels [59]. Rajan Verma et al. (2017) analyzed the mechanical properties of Al356 composites reinforced with SiC and alumina. They found that the yield strength and ultimate tensile strength increased with reinforcement content, likely due to the dispersion of SiC and alumina particles that hindered dislocation movement [60]. T. Somasekhar et al. (2018) reviewed properties and processing of silicon carbide particulate MMCs based on aluminum. Their research suggested a two-step stir casting technique to achieve uniform dispersion of the ceramic material, resulting in enhanced tensile strength, impact strength, and hardness for the composite compared to the base aluminum alloy [61].

S. Mohamed Hussain et al. (2018) optimized machining parameters for stir-cast Al-B4C reinforced MMCs. They found that lower B4C content (10–15%) yielded the best results, with the study focusing on performance factors such as material removal rate, cutting force, and surface roughness during milling [62]. Pranav Dev Srivyas et al. (2018) reviewed the mechanical and tribological behavior of aluminum matrix composites (AMCs) reinforced with various materials. Their research emphasized the impact of reinforcement type, size, and percentage on mechanical properties, and explored the factors influencing wear performance in different environmental conditions [63]. Mudasar Pasha B.A. et al. (2018) provided a review of aluminum metal matrix composites, focusing on the processing techniques, characterization, and advancements in manufacturing. Stir casting, powder metallurgy, and other techniques are discussed, with a special emphasis on factors such as reinforcement size, stirring speed, and temperature, which influence the mechanical properties and quality of the composites. The review also highlights the role of processing parameters in reducing porosity and producing defect-free composites [64]. Kawaljitsingh Randhawa et al. (2018) reviewed fabrication challenges in MMCs, including issues with casting, fiber orientation, and reinforcement bonding. They proposed solutions such as coating reinforcement elements to improve wettability and bonding, which are crucial for successful composite fabrication [65].

M. Pasupathi et al. (2018) explored the gravity die casting process to analyze the microstructure and mechanical properties of LM25 alloy with AC4B Nano-Composite. They found that the LM25 alloy had loosely packed grains, which led to porosity and shrinkage faults. The addition of C4B in the AC4B alloy refined the grain structure, improving mechanical properties like tensile strength and hardness. The presence of nanocomposite particles significantly enhanced these properties [66]. Venkata Reddy et al. (2018) investigated the mechanical properties of A7075 aluminum reinforced with a hybrid matrix of silicon carbide (SiC) and fly ash. Their findings showed improvements in hardness and deformation characteristics and a clear interfacial bonding between matrix and reinforcements. X-ray diffraction (XRD) and Energy Dispersive X-ray (EDX) analyses confirmed the presence of silica and alumina phases [67]. Arun Kumar Sharma et al. (2019) provided an overview of matrix materials used in MMCs, emphasizing the importance of continuous research and development to fully realize their potential in demanding applications [68]. Pulkit Garg et al. (2019) focused on the synthesis methods and mechanical properties of AMMCs. They emphasized powder metallurgy techniques for better control over microstructure and interface properties. They also pointed out the limitations of stir casting for manufacturing nanocomposites due to poor nanoparticle distribution and excessive porosity [69]. A. Radha Krishnan et al. (2019) focused on Al-Zn- $Al_2O_3$ composites for piston analysis. They observed improved wear and hardness properties when reinforcing LM25 alloy with alumina and zinc, which may lead to significant design improvements in automotive pistons [70]. Karthikeyan Govindan et al. (2019) studied LM25/$ZrO_2$ composites fabricated via stir casting. The microstructural examination showed a fine distribution of $ZrO_2$ particles in the aluminum matrix, which enhanced the composite's mechanical properties. SEM and EDS analysis confirmed the lack of shrinkage and porosity in the castings, making them suitable for high-performance applications [71]. Chandru B.G. et al. (2020) focused on the development of Al7475/NbC reinforced metal matrix composites (MMCs) to enhance mechanical properties such as tensile strength, compression strength, and hardness.

By varying the particle size of NbC and reinforcement levels (2-8 wt%), they used the stir casting technique to fabricate the composites. The mechanical properties were significantly improved with increased NbC content. The ultimate tensile strength increased by 31.54%, yield strength by 34.70%, and compressive strength by 52.72% compared to the base Al7475 alloy. Additionally, hardness increased by 37.86%, attributed to the hard NbC particles enhancing resistance to indentation [72]. Ashrafi N. et al. (2020) investigated hybrid reinforcement composites (Al-$Fe_3O_4$-SiC) fabricated by powder metallurgy. The study found a 111% increase in surface hardness, with Al-30$Fe_3O_4$-20SiC showing the lowest coefficient of friction (COF) at 0.412. Furthermore, corrosion resistance improved with the hybrid reinforcement, with Al-30Fe3O4-20SiC exhibiting a corrosion protection efficiency of 99.83%, highlighting the hybrid composite's potential for durability and corrosion resistance [73]. Babu B et al. (2020) studied hybrid AMMCs reinforced with magnesium oxide (MgO) and graphite, focusing on their mechanical properties and machinability.

Using the TOPSIS method, they optimized processing parameters to achieve better material removal rates and lower overcut during microelectrochemical machining (micro ECM) [74]. Nithyanandhan T. (2020) focused on the tribological behavior of SiC and graphite-reinforced aluminum MMCs, reporting improvements in wear rates and fatigue resistance with increasing reinforcement content. The microstructure showed a uniform distribution of reinforcements, positively influencing mechanical properties [75]. Zeeshan Ahmad et al. (2020) studied the effect of Si3N4 reinforcement on the microstructure and mechanical properties of LM25 Al alloy composites. Using stir casting, they observed uniform dispersion of $Si_3N_4$ at lower percentages (4-8%), but clustering at higher percentages (12%). EDS and SEM analysis confirmed the presence of $Si_3N_4$ particles and their role as nucleating agents during solidification, leading to improved mechanical properties of the composite [76]. Sami Ullah Khan et al. (2021) reviewed in-situ synthesized Al 6061 alloy MMCs, noting that the distribution of reinforcement particles significantly affected mechanical and tribological properties. Proper reinforcement placement was key to enhancing material performance [77].

M.S. Ayar et al. (2021) reviewed advancements in aluminum MMCs, emphasizing these composites' material and energy savings potential. They discussed the challenges of achieving uniform reinforcement distribution and high processing costs, noting that innovations in aluminum-based MMCs (AMMHCs) hold promise for various engineering applications [78]. Rinku Datkhile et al. (2021) conducted a bibliometric analysis of research trends in MMCs reinforced with sustainably mined silica. Their work highlighted the growing interest in using agricultural waste for composite reinforcement, contributing to both economic growth and environmental sustainability [79]. Ramesh S. et al. (2021) studied the heat treatment of Al6061-AlB2 composites, finding significant improvements in hardness with increasing AlB2 content. The heat treatment process led to a supersaturated solution, which increased hardness, particularly when quenching in ice [80]. Shivaramakrishna A. et al. (2022) synthesized $Fe_3O_4$–Aluminum matrix composites and evaluated their mechanical and corrosion properties. They reinforced Al7075 with 2%, 4%, 6%, and 8% $Fe_3O_4$ using the stir casting technique. Their results showed that the tensile strength peaked at a 6% $Fe_3O_4$ reinforcement, with a 21.865% increase. The hardness was highest (47.53%) for 8% $Fe_3O_4$. Moreover, corrosion resistance improved significantly due to the presence of $Al_3Fe$ intermetallic phases, which enhanced pitting corrosion resistance [81].

## IV. CONCLUSIONS

The development and description of aluminum matrix composites (AMCs) have led to significant advancements in materials science. Researchers have focused on enhancing properties like strength, hardness, and corrosion resistance by varying reinforcement types, sizes, and percentages. Aluminum metal matrix composites have been recognised to be a versatile and favorable class of materials due to their enhanced mechanical and thermal properties. The combination of aluminum alloys with various reinforcements such as SiC, $Al_2O_3$, and hybrid materials, has shown significant performance improvements. The properties of these composites are influenced by factors such as the applied load, sliding velocity, and the type and volume of reinforcement used. Techniques such as stir casting, powder metallurgy, FSP, and centrifugal casting have produced high-performance of MMCs. Additionally, hybrid reinforcements and processing innovations continue to improve the performance and cost-effectiveness of AMCs for various industrial applications. Future research should focus on improving the processing techniques and strong bonding between the matrix and reinforcement, as well as exploring new composite materials for advanced industrial applications.

## V. AUTHOR'S CONTRIBUTION

**Conceptualization:** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.
**Methodology:** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.
**Investigation:** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.
**Writing – Original Draft:** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.
**Writing – Review and Editing:** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.
**Resources:** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.
**Supervision** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.
**Approval of the final text:** Mehul G. Mehta, Jignesh G. Parmar, Nital P. Nirmal.

## VII. REFERENCES

[1] Adel Mahamood Hassan, Abdalla Alrashdan, Mohammed, T. Hayajneh & Ahmad Turki Mayyas 2009, 'Prediction of density, porosity and hardness in aluminium-copper-based composite materials using artificial neural network', Journal of Materials Processing Technology, vol. 209, no. 2, pp. 894 899.

[2] Ali Mazahery & Mohsen Ostad Shabani 2012, 'Influence of the hard coated B4C particulates on wear resistance of Al-Cu alloys', Composites: Part B, vol. 43, no. 3, pp. 1302-1308.

[3] Hui-Hui Fu, Kyung-Seop Han & Jung-II Song 2004, 'Wear properties of Saffil/Al, Saffil/Al2O3/Al and Saffil/SiC/Al', Wear, vol. 256, no. 7-8, pp. 705-713.

[4] Srivatsan, T. S., Ibrahim, I. A., Mohamed, F. A., & Lavernia, E. J. (1991). Processing techniques for particulate-reinforced metal aluminium matrix composites. Journal of Materials Science, 26(22), 5965–5978. https://doi.org/10.1007/BF01113872.

[5] Doel, T. J. A., & Bowen, P. (1996). Tensile properties of particulate-reinforced metal matrix composites. Composites Part A: Applied Science and Manufacturing, 27(8 PART A), 655–665. https://doi.org/10.1016/1359-835X(96)00040-1.

[6] Rohatgi, P. K. (1993). Metal-matrix Composites I. Defence Science Journal (Vol. 43, Issue 4).

[7] Surappa, M. K. (2003). Aluminium matrix composites: Challenges and opportunities. SadhanaAcademy Proceedings in Engineering Sciences, 28(1–2), 319–334. https://doi.org/10.1007/BF02717141

[8] Natarajan, N., Vijayarangan, S., & Rajendran, I. (2006). Wear behaviour of A356/25SiCp aluminium matrix composites sliding against automobile friction material. Wear, 261(7–8), 812–822. https://doi.org/10.1016/j.wear.2006.01.011.

[9] Montoya-Dávila, M., Pech-Canul, M. A., & Pech-Canul, M. I. (2007). Microstructure and Mechanical Properties of Al/Sicp Composites with Multimodal Size Distribution of Reinforcements. Materials Science Forum, 560, 115–120. https://doi.org/10.4028/www.scientific.net/msf.560.115.

[10] Hajjari, E., & Divandari, M. (2008). An investigation on the microstructure and tensile properties of direct squeeze cast and gravity die cast 2024 wrought Al alloy. Materials and Design, 29(9), 1685–1689. https://doi.org/10.1016/j.matdes.2008.04.012.

[11] Cheng, N. P., Zeng, S. M., & Liu, Z. Y. (2008). Preparation, microstructures and deformation behavior of SiCP/6066Al composites produced by PM route. Journal ofMaterialsProcessingTechnology,202(1-3),27–40. https://doi.org/10.1016/j.jmatprotec.2007.08.044.

[12] Tan, C. F., & Said, M. R. (2009). Effect of hardness test on precipitation hardening aluminium alloy 6061-t6. Chiang Mai Journal of Science, 36(3), 276–286.

[13] Wahab, M. N., & Ghazali, M. (2009). Preparation and characterization of stir cast-aluminum nitride reinforced aluminum metal matrix composites Heat Transfer Mechanism on Coated Piston Crown for Spark Ignition Engine View project
synthesis ofsuperparamagnetic nanoparticles View project. https://www.researchgate.net/publication/265814754.

[14] Bayraktar, E., & Katundi, D. (2010). Development of a new aluminium matrix composite reinforced with iron oxide (Fe3O4). Journal of Achievements in Materials and Manufacturing Engineering (Vol. 38, Issue 1).

[15] Ramesh, C. S., Keshavamurthy, R., Channabasappa, B. H., & Pramod, S. (2010). Friction and wear behavior of Ni-P coated Si3N4 reinforced Al6061 composites. Tribology International, 43-3, 623-634. https://doi.org/10.1016/j.triboint.2009.09.011.

[16] Sahin, I., & Eker, A. A. (2011). Analysis of microstructures and mechanical properties of particle reinforced AlSi7Mg2 matrix composite materials. Journal of Materials Engineering and Performance, 20(6), 1090–1096. https://doi.org/10.1007/s11665-010-9738-6.

[17] Milos, K. (2011). Aluminium-Based Composite Materials In Construction Of Transport Means. PrometTraffic&Transportation (Vol. 23, Issue 2).

[18] Suresh, S. M., Mishra, D., Srinivasan, A., Arunachalam, R. M., & Sasikumar, R. (2011). Production and characterization of micro and nano Al2O3 particle-reinforced LM25 aluminium alloy composites. ARPN Journal of Engineering and Applied Sciences, 6(6), 94–98.

[19] Devi, N. C., & Professor, A. (2011). Mechanical characterization of Aluminium silicon carbide composite. In International Journal of Applied Engineering Research, Dindigul (Vol. 1, Issue 4).

[20] Reddy, A. C. (2011). Evaluation of Mechanical Behavior of Al-Alloy/SiC Metal Matrix Composites With Respect To Their Constituents Using Taguchi Techniques. I-Manager's Journal on Mechanical Engineering, 1(2), 33–43. https://doi.org/10.26634/jme.1.2.1405.

[21] Kumar Tuli, A., Singh, P., Das, S., Mondal, D. P., & Shakya, J. P. (2021). Analysis of microstructural, mechanical and thermal behaviour of thixocast LM25-10wt% SiC composite at different processing temperatures. Indian Academy of Sciences. https://doi.org/10.1007/s12046-021-01757-3S.

[22] Jit, N., Tyagi, A. K., Singh, N., & Singh, A. (2011). Comparison of porosity and density for (A384.1) 1-x [(Reinforcement) p] x MMC system using Adaptive Neuro-Fuzzy Inference system. Advances in Applied Science Research, 2(4), 240–250.

[23] Seetharaman, S., Karthigeyan, R., Ranganath, G., & Sankaranarayanan, S. (2012). Mechanical Properties and Microstructure Studies of Aluminium (7075) Alloy Matrix Composite Reinforced with Short Basalt Fibre. European Journal of Scientific Research (Vol. 68, Issue 4). http://www.europeanjournalofscientificresearch.com.

[24] Sozhamannan, G. G., Prabu, S. B., & Venkatagalapathy, V. S. K. (2012). Effect of Processing Paramters on Metal Matrix Composites: Stir Casting Process. Journal of Surface Engineered Materials and Advanced Technology, 02(01), 11–15. https://doi.org/10.4236/jsemat.2012.21002.

[25] Mazahery, A., & Shabani, M. O. (2012). Characterization of cast A356 alloy reinforced with nano SiC composites. Transactions of Nonferrous Metals Society of China (English Edition), 22(2), 275–280. https://doi.org/10.1016/S1003-6326(11)61171-0.

[26] Shabani, M. O., Mazahery, A., Rahimipour, M. R., & Razavi, M. (2012). FEM and ANN investigation of A356 composites reinforced with B4C particulates. Journal of King Saud University, Engineering Sciences, 24(2), 107–113. https://doi.org/10.1016/j.jksues.2011.05.001

[27] Pargunde, D. M., Gajanan, P., Thokal, N., Dhanraj, P., Tambuskar, P., Swapnil, M., Kulkarni, S., & Scholar, M. E. (2013). Development of Aluminium Based Metal Matrix Composite (AlSiC) 1 Address for Correspondence. In International Journal of Advanced Engineering Research and Studies.

[28] Singh, G., Lal, H., Singh, D., & Singh, G. (2013). An Approach for Improving Wear Rate of Aluminum Based Metal Using Red Mud, Sic And Al2O3Matrix Composites. In Int. J. Mech. Eng. & Rob. Res. www.ijmerr.com.

[29] Tahamtan, S., Halvaee, A., Emamy, M., & Zabihi, M. S. (2013). Fabrication of Al/A206-Al2O3 nano/micro composite by combining ball milling and stir casting technology. Materials and Design, 49, 347–359. https://doi.org/10.1016/j.matdes.2013.01.032.

[30] Mr.Sharanabasappa R Patil. (2013). A Study on Mechanical Properties of Fly Ash and Alumina Reinforced Aluminium Alloy (LM25) Composites. IOSR Journal of Mechanical and Civil Engineering, 7(6), 41–46. https://doi.org/10.9790/1684-0764146.

[31] Chandra Kandpal, B., Kumar, J., & Singh, H. (2014). Production Technologies of Metal Matrix Composite: A Review. International Journal of Research in Mechanical Engineering & Technology, 4(2).ISSN : 2249-5762. Vol. 4, Issue 2.

[32] Jayakumar, A., & Rangaraj, M. (2008). International Journal of Emerging Technology and Advanced Engineering Property Analysis of Aluminium (LM-25) Metal Matrix Composite. Certified Journal (Vol. 9001, Issue 2). www.ijetae.com

[33] Bolzoni, L., & Hari Babu, N. (2015). Refinement of the grain size of the LM25 alloy (A356) by 96Al-2Nb-2B master alloy. Journal of Materials Processing Technology, 222, 219–223. https://doi.org/10.1016/j.jmatprotec.2015.03.011.

[34] Suresh Kumar, S., Uthayakumar, M., Thirumalai Kumaran, S., Parameswaran, P., Mohandas, E., Kempulraj, G., Ramesh Babu, B. S., & Natarajan, S. A. (2015). Parametric optimization of wire electrical discharge machining on aluminium based composites through grey relational analysis. Journal of Manufacturing Processes, 20, 33–39. https://doi.org/10.1016/j.jmapro.2015.09.011.

[35] Tashkinov, M. (2017). Statistical methods for mechanical characterization of randomly reinforced media. Mechanics of Advanced Materials and Modern Processes, 3(1). https://doi.org/10.1186/s40759-017-0032-2.

[36] Boshnakova, S., Markovska, I., & Rusev, D. (2015). SiC and TiC Stainless Steel Based Metal Matrix Composites. Scientific Work for Russia University, 54(101), 14–18. http://conf.uniruse.bg/docs/cp15/10.1/10.1-2.

[37] Singh, G., & Giri, T. (2015). Fabrication of Aluminum/Magnesium Composite Material and Optimization their Mechanical Properties. In International Journal of Science and Research (IJSR) ISSN. www.ijsr.net

[38] Das, B., Roy, S., Rai, R. N., & Saha, S. C. (2016). Development of an in-situ synthesized multi-component reinforced Al–4.5%Cu–TiC metal matrix composite by FAS technique – Optimization of process parameters. Engineering Science and Technology, an International Journal, 19(1), 279–291. https://doi.org/10.1016/j.jestch.2015.08.002.

[39] Krishna, S. A. M., Shridhar, T. N., & Krishnamurthy, L. (2015). Evaluation and Examination of Volume Fraction, Porosity, Microstructure and Computational Modeling of Hybrid Metal Matrix Composites to Reveal the Hea. International Journal of Materials Science and Engineering, 3(3), 231–243. https://doi.org/10.17706/ijmse.2015.3.3.231-243.

[40] Vishnu Prasad, K., & Jayadevan, K. R. (2016). Simulation of Stirring in Stir Casting. Procedia Technology, 24, 356–363. https://doi.org/10.1016/j.protcy.2016.05.048.

[41] Vembu, V., & Ganesan, G. (2015). Heat treatment optimization for tensile properties of 8011 Al/15% SiCp metal matrix composite using response surface methodology. Defence Technology, 11(4), 390–395. https://doi.org/10.1016/j.dt.2015.03.004.

[42] Shen, M. J., Wang, X. J., Zhang, M. F., Zhang, B. H., Zheng, M. Y., & Wu, K. (2015). Microstructure and room temperature tensile properties of 1 μm-SiCp/AZ31B magnesium matrix composite. Journal of Magnesium and Alloys, 3(2), 155–161. https://doi.org/10.1016/j.jma.2015.03.001.

[43] Radhiks N. (2015). Mechanical properties and tribological behaviour of LM25_SiC_Al2O3 composites. Journal of Engineering Science and Technology. 10(2):134-144.

[44] Venkatesh, B., & Harish, B. (2015). Mechanical Properties of Metal Matrix Composites (Al/SiCp) Particles Produced By Powder Metallurgy. International Journal of Engineering Research and General Science, 3(1). www.ijergs.org.

[45] Sharma, P., Sharma, S., & Khanduja, D. (2015). A study on microstructure of aluminium matrix composites. Journal of Asian Ceramic Societies, 3(3), 240–244. https://doi.org/10.1016/j.jascer.2015.04.001.

[46] Venkatachalam G ,Kumar, A. N., & Rajagopal, D. (2015). Studies On Microstructure and Mechanical Properties Of modified Lm25 Aluminium Alloy. International Journal of Advanced Technology in Engineering and Science www.ijates.com (Vol. 03, Issue 01). www.ijates.com

[47] Priya, S., Mohammed, S., & Shanmugaraja, M. (2016). Investigation on Mechanical Properties 0f Aluminium 6061 reinforced with Sic and Al2O3. http://www.internationaljournalssrg.org.

[48] Xavior, M. A., & Kumar, J. P. A. (2017). Machinability of Hybrid Metal Matrix Composite - A Review. Procedia Engineering, 174, 1110–1118. https://doi.org/10.1016/j.proeng.2017.01.264.

[49] Arora, A., Astarita, A., Boccarusso, L., & Mahesh, V. P. (2016). Experimental Characterization of Metal Matrix Composite with Aluminium Matrix and Molybdenum Powders as Reinforcement. Procedia Engineering, 167, 245–251. https://doi.org/10.1016/j.proeng.2016.11.694.

[50] Bodukuri, A. K., Eswaraiah, K., Rajendar, K., & Sampath, V. (2016). Fabrication of Al–SiC–B4C metal matrix composite by powder metallurgy technique and evaluating mechanical properties. Perspectives in Science, 8, 428–431. https://doi.org/10.1016/j.pisc.2016.04.096.

[51] Kishore, M. N. V., & Tech Scholar, M. (2016). Mechanical Properties in MMC of Aluminum Alloy (A356/LM25) Matrix and Boron Carbide (B 4 C) Reinforcement. http://www.ijert.org.Vol. 5 Issue 02.

[52] Radhika N, & Gruyter, D. (2016). Comparison of the mechanical and wear behaviour of aluminium alloy with homogeneous and functionally graded silicon nitride composites. https://doi.org/10.1515/secm-2015-0160.

[53] Awarasang, S., & Awarasan, S. N. S. (2016). Study The Microstructure And Impact Strength Of Lm 25 Aluminium Alloy Reinforced with Steel Wire. https://doi.org/10.13140/RG.2.2.28176.05124.

[54] Venkatesan, S., & Xavior, M. A. (n.d.). Mechanical behaviour of Aluminium metal matrix composite reinforced with graphene particulate by stir casting method. Journal of Chemical and Pharmaceutical Sciences, 10(1). www.jchps.com.ISSN: 0974-2115.

[55] Mishra, J. (2017). Fabrication Of Metal Matrix Composites: A Review. http://www.journal Vol. 9, Issue, 10, pp.59180-59185.

[56] Moona, G., Walia, R. S., Rastogi, V., & Sharma, R. (2018). Aluminium metal matrix composites: A retrospective investigation. Indian Journal of Pure & Applied Physics (Vol. 56).

[57] Arvind Sankhla. (2015). On studies of Powder Metallurgy as an effective method for Processing Metal Matrix Composites.Indian Journal of Applied Research.Volume – 5,Issue – 1.

[58] Reddy, C. C., Chand, P. R., M, C. K., & N Assistant Professors, S. S. (2017). Development And Characterization of Aluminum Alloy Reinforced With Al2O3 Metal Matrix Composites By Centrifugal Casting Method. International Journal of Scientific Development and Research. www.ijsdr.org

[59] Reddy, S. S., & Scholar, U. (2017). Publication Impact Factor (PIF): 1.02 www.sretechjournal.org Study of Hardness of Aluminium(LM25) Composite. International Journal of Engineering Research and Advanced Technology (IJERAT), 5(5), 2454–6135. www.sretechjournal.org

[60] Rajan Verma, Saurabh Sharma, & Dinesh Kumar. (2017). Analysis of Mechanical Properties of Aluminium based Metal Matrix Composites Reinforced with Alumina and Sic. International Journal of Engineering Research, V6(03), 454–459. https://doi.org/10.17577/ijertv6is030506.

[61] T.Somasekhar, & P Niteesh kumar. (2018). Review Paper on Processing of Metal Matrix Composites &its Properties. www.ijcrt.org. ISSN:2320-2882.

[62] Hussain, S. M., Muruganantham, P., & Rekha, R. (2018). Milling Of Stir Cast Aluminium Boron Carbide Metal Matrix Composite-A Literature Review. International Journal of Engineering, Science and Mathematics, 7http://www.ijesm.co.in,

[63] Dev Srivyas, P., & S. Charoo, M. (2018). Aluminum metal matrix composites a review of reinforcement; mechanical and tribological behavior. International Journal of Engineering & Technology, 7(2.4), 117. https://doi.org/10.14419/ijet.v7i2.4.13020.

[64] Mudasar Pasha, B. A., & Kaleemulla, M. (2018). Processing and characterization of aluminum metal matrix composites: An overview. Reviews on Advanced Materials Science, 56(1), 79–90. https://doi.org/10.1515/rams-2018-0039.

[65] Mohan Krishna, S. A., Shridhar, T. N., & Krishnamurthy, L. (2015). Research Significance, Applications and Fabrication of Hybrid Metal Matrix Composites. IJISET-International Journal of Innovative Science, Engineering & Technology (Vol. 2, Issue 5). www.ijiset.com

[66] Pasupathi, M., & Berlin Raj, S. (2019). Microstructure Analysis and Mechanical Properties of LM25 alloy with AC4B Nano-Composite using Gravity Die Casting Method. IOP Conference Series: Materials Science and Engineering, 507(1). https://doi.org/10.1088/1757-899X/507/1/012023.

[67] Venkata Reddy, V., Gopi Krishna, M., Praveen Kumar, K., Naga Kishore, B. S., Babu Rao, J., & Bhargava, N. (2018). Studies on microstructure and mechanical behaviour of A7075- Flyash/SiC hybrid metal matrix composites. IOP Conference Series: Materials Science and Engineering, 310(1). https://doi.org/10.1088/1757-899X/310/1/012047.

[68] Sharma, A. K., Bhandari, R., Aherwar, A., & Rimašauskiene, R. (2020). Matrix materials used in composites: A comprehensive study. Materials Today: Proceedings, 21, 1559–1562. https://doi.org/10.1016/j.matpr.2019.11.086.

[69] Garg, P., Jamwal, A., Kumar, D., Sadasivuni, K. K., Hussain, C. M., & Gupta, P. (2019). Advance research progresses in aluminium matrix composites: manufacturing & applications. Journal of Materials Research and Technology (Vol. 8, Issue 5, pp. 4924–4939). Elsevier Editora Ltda. https://doi.org/10.1016/j.jmrt.2019.06.028.

[70] Radha Krishnan, B., & Ramesh, M. (2019). Experimental evaluation of Al-Zn-Al2O3 composite on piston analysis by CAE tools. Mechanics and Mechanical Engineering, 23(1), 212–217. https://doi.org/10.2478/mme-2019-0028.

[71] Govindan, K., & Raghuvaran, J. G. (2019). Mechanical properties and metallurgical characterization of lm25/zro2 composites fabricated by stir casting method. Revista Materia, 24(3). https://doi.org/10.1590/S1517-707620190003.0753.

[72] Chandru B.G, Dr.S.Channabasavaraj, Dr.A.Thimmana Gouda, Dr.Manohar H.S (2020). Development and Characterization of Al7475/NbC Reniforced Metal Matrix Composites. International Journal for Research in Engineering Application & Management, 206–207. https://doi.org/10.35291/2454-9150.2020.0463.

[73] Ashrafi, N., Hanim, M. A. A., Sarraf, M., Sulaiman, S., & Hong, T. S. (2020). Microstructural, tribology and corrosion properties of optimized Fe3O4-sic reinforced aluminum matrix hybrid nano filler composite fabricated through powder metallurgy method. Materials, 13(18). https://doi.org/10.3390/ma13184090.

[74] Babu, B., Sabarinathan, C., & Dharmalingam, S. (2020). Production of aluminum 6063 metal matrix composite with 12% magnesium oxide and 5% graphite and its machinability studies using micro electrochemical machining. Journal of New Materials for Electrochemical Systems, 23(2), 94–100. https://doi.org/10.14447/jnmes.v23i2.a06.

[75] T, Nithyanandhan., R, Kannakumar., P, Sureshkumar., S, Pradeep., & V, Prakesh. (2020). Mechanical Properties and Tribological Behaviour of Reinforced Aluminium Metal Matrix Composites. International Journal of Recent Technology and Engineering (IJRTE), 8(6), 1191–1195. https://doi.org/10.35940/ijrte.e6590.038620.

[76] Ahmad, Z., Khan, S., & Hasan, S. (2020). Microstructural characterization and evaluation of mechanical properties of silicon nitride reinforced LM 25 composite. Journal of Materials Research and Technology, 9(4), 9129–9135. https://doi.org/10.1016/j.jmrt.2020.06.037.

[77] Ullah Khan S., Wanwu, D., Ullah Khan, Q., Khan, S., Alam, A., Ullah, A., & Ullah, H. (2021). An Analysis of In-Situ Synthesized AL 6061 Alloy Metal Matrix Composites: Review. European Journal of Materials Science and Engineering, 6(4), 220–233. https://doi.org/10.36868/ejmse.2021.06.04.220.

[78] Ayar, M. S., George, P. M., & Patel, R. R. (2021). Advanced research progresses in aluminium metal matrix composites: An overview. AIP Conference Proceedings, 2317(1), 1–5. https://doi.org/10.1063/5.0036141.

[79] Datkhile, R., Laad, M., & Ghule, B. (2021). Research Trend of Metal Matrix Composites reinforced with silica extracted by green route: A Bibliometric Analysis. Library Philosophy and Practice, 2021(January), 1–15.

[80] Samuel, D., Boppana, S. B., Palanikumar, K., Ramesh, S., & Auradi, V. (2021). Role of heat treatment on hardness of Al 6061- AlB2metal matrix composites. International Journal ofSurface Engineering and InterdisciplinaryMaterials
Science, 9(1), 26–39. https://doi.org/10.4018/IJSEIMS.2021010102.

[81] Shivaramakrishna, A.,Basavaraj, Y., & Subramanya, R.(2022). Synthesis of Fe3O4–aluminium matrix composites mechanical and corrosion characteristics. International Journalof Cast Metals Research,35, 51-59.https://doi.org/10.1080/13640461.2022. 2078551.