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A Review on Carbon Fiber Reinforced Metal Matrix Composites

Samuel Dayanand[1], B. Satish Babu[2], Aravind Telagu[2], Basawaraj[3], Sandeep Mukunda[2], Ankit Kumar Singh[4] and Madeva Nagaral[5]*

[1]*Department of Mechanical Engineering, Government Engineering College, Gangavathi – 583227, Karnataka, India*
[2]*Department of Mechanical Engineering, School of Engineering, Presidency University, Bengaluru – 560064, Karnataka, India*
[3]*Department of Mechanical Engineering, SKSJTI, Bengaluru – 560001, Karnataka, India*
[4]*Wyzmindz Solutions Pvt. Limited, Bengaluru – 560062, Karnataka, India*
[5]*Aircraft Research and Design Centre, Hindustan Aeronautics Limited, Bengaluru – 560008, Karnataka, India; madev.nagaral@gmail.com*

Abstract

The manufacturing sector perpetually seeks high-quality materials capable of meeting the requirements for enhanced mechanical properties, thereby enabling their widespread application across various industries. Integrating Carbon Fibers (CFs) into metal matrices has demonstrated significant efficacy in augmenting the comprehensive attributes of the resultant composites. This comprehensive review focuses on the latest advancements and techniques involving the utilization of carbon fibers in conjunction with metal matrix material, aimed at augmenting a spectrum of mechanical attributes. Various methods used to synthesize carbon fiber reinforced metal composites have been discussed and summarized. Liquid metallurgy technique is playing important role in the fabrication of the carbon fiber reinforced metal composites.

Keywords: *Aluminum, Carbon Fibers, Dispersion, Mechanical Properties, Metal Matrix Composites, Strengthening*

1.0 Introduction

The conventional materials suffer substantial degradation in properties under relatively low temperatures, impeding their utility in critical components[1,2]. Nevertheless, the combination of the inherent ductility of the matrix with robustness, high specific strength and stiffness of materials like carbon fibers or ceramic filaments has yielded materials capable of transcending performance barriers. These advanced materials find applications in cutting-edge domains such as nano electronics, structural engineering and medical contexts[3-5]. MMCs (Metal Matrix Composites) boast a diverse array of properties including minimal thermal expansion, exceptional strength, elevated temperature resistance, heightened stiffness and thermal conductivity that elude traditional monolithic materials[6,7]. Given this wide spectrum of attributes, MMC's are harnessed across numerous engineering disciplines where the demand for lightweight and robust materials is pronounced, such as defense, automotive, marine, and aerospace sectors[8-10]. The MMC family encompasses various metals utilized as matrices, including Aluminum (Al), copper, magnesium, and titanium. These matrices are reinforced with a variety of micro/nano materials to attain desired properties. While each metal boasts unique applications aligned with its

*Author for correspondence

properties, Al-MMCs stand out as the most extensively employed composite materials[11,12]. These Al-MMCs have a number of noteworthy characteristics, including low weight, low density, remarkable resistance to corrosion, high specific strength, minimal thermal expansion coefficient, remarkable resistance to degradation, and ease of machinability[13,14]. Among the array of reinforcements utilized with Al reinforced MMCs, both macro reinforcements like SiC, Al_2O_3, Si_3N_4, AlN, AlB_2, TiB_2, and ZrO_2 and also nano reinforcements which includes CNT, nano-sized SiC particles, CFs and nano-ZrO have been explored[15-20]. Nano reinforcements have exhibited superior results in contrast to macro reinforcements[21,22]. However, the significant drawback of these MMCs is the necessity for high reinforcement volume fractions, often as much as 60%, which renders silicon carbide and diamond reinforced MMC's challenging to machine for industrial use[23].

Nowadays, the integration of carbon-fiber/metal matrix compositions, higher temperature composites hinging on high-entropy alloys and refractory metals, along with the utilization of intermetallics is given prime importance. These materials are poised to usher in a transformative era in the realm of aerospace materials and diverse technical domains, much akin to the role CFRPs undertook several decades back. Carbon-fiber/metal-matrix composites, often abbreviated as CFMMCs, carve out a distinctive and significant domain within the panorama of forthcoming metal-matrix composite materials[24-26].

Carbon Fiber (CF) reinforced MMC's have emerged as a contender for heat sink applications similar to other nano reinforcements, CFs offer outstanding qualities including high modulus, strength, and favorable wear and lubrication characteristics[25,26]. As a result, CFs are gradually incorporated into Al-MMCs, enhancing both the toughness and diverse tribological characteristics of the resultant composites[27-33]. In a study by Lalet *et al.*[34], it was illustrated that a modest 30% reinforcement of carbon fiber might significantly decrease the CTE of copper and aluminum. This remarkable decrease in CTE along the longitudinal axis establishes CF reinforced Al and copper MMCs as noteworthy examples and promising candidates for heat sink applications[35,36]. Moreover, Carbon fiber-reinforced MMCs exhibit heightened wear resistance, rendering them applicable in bearing components. In one of the research work[37] it was discovered that introducing short CFs in Al alloy enhances the wear resistance of the alloy and makes an improvement in the coefficient of friction. Additionally, fibers' inherent self-lubricating qualities and enhanced temperature strength have a wealth of recorded evidence supporting them[38,39] and underscore their valuable properties that also contribute to the superior properties of these MMCs, including modulus, strength, toughness and electrical conductivity[30,35-39]. Consequently, CF-reinforced MMCs have garnered significant interest from industries spanning aircraft, aerospace, automotive and electronics[40]. Aluminium reinforced CF Metal Matrix Composites (CF/Al MMCs) represent a cutting-edge class of materials that amalgamate the strengths of carbon fibers and aluminum matrices. These composites are designed to have improved physical, electrical, mechanical, electrical, and thermal characteristics. When carbon fibers are mixed with an aluminum matrix, a synergistic effect is produced that improves performance in a variety of applications. Carbon fibers boast exceptional attributes such as strength, stiffness, weight reduction, stability, thermal conductivity, corrosion resistance, and fatigue resistance, all while considering cost implications[41,42]. In summary, CF/Al MMCs offer a compelling solution for applications necessitating lightweight, robust and thermally efficient materials. Their unique blend of qualities positions them as viable candidates for diverse industries including aerospace, automotive, electronics and sports equipment. Nonetheless, factors such as cost and manufacturing challenges demand attention to facilitate broader adoption in various markets. Ongoing research and development endeavors are dedicated to refining production methods and cost efficiency to render CF/Al MMCs more accessible and commercially viable[35-39].

This review aims to delve into the advancements centered around synthesizing CF-reinforced MMCs.

2.0 Carbon Fibres (CFs)

Carbon fiber structures come in both short and continuous forms, and they can be amorphous, crystal-like, or partially crystalline[22-24,40-42]. The roots of carbon fibers trace back to 1878 when Thomas Edison subjected CFs and bamboo fibers to high-temperature baking to transform them into utilizing carbon to create luminescent filaments. Subsequent breakthroughs in 1958 and 1963 at a British research center led to the development of the Polyacrylonitrile (PAN) precursor, a more cost-effective alternative to previous methods, which illuminated the potential of carbon fibers[22-24, 44,45]. Since then, advancements in manufacturing processes have significantly reduced carbon fiber prices. Carbon fibers are categorized based on the precursor utilized in their synthesis. The attributes of carbon fibers encompass remarkable stiffness, low coefficient of thermal expansion, chemical resistance, tensile strength, high-temperature tolerance, and an impressive strength-to-weight ratio[37,41,42]. Indeed, carbon fibers exhibit a remarkable strength that is five times greater, stiffness that is twice as much, and a weight that is four times lighter than steel[43,44] underpinning their utility in crafting lightweight composite materials for structural applications[22-24,44-46].

Among these carbonaceous materials, carbon fiber emerges as a particularly captivating contender, boasting outstanding mechanical prowess and unparalleled chemical stability. Carbon Fibers (CFs), characterized by a carbon content exceeding 92 wt. %, exhibit remarkable mechanical and physical attributes. These encompass exceptional tensile strength (varying between 2 to 7 GPa), elevated Young's modulus (ranging from 200 to 900 GPa), low density (falling within the range of 1.75 to 2.20 g/cm^3), minimal thermal expansion alongside remarkable thermal and electrical conductivity (approximately 800 $Wm^{-1}K^{-1}$). Moreover, carbon fibers display robust chemical resistance to most chemical substances, barring exposure to high temperatures or flames[22-24,47-49]. A compelling aspect is that carbon fiber's weight is approximately four times lower than that of steel, while its strength surpasses that of steel[23,24]. Furthermore, carbon fibers outshine other elements like Zn, Mn and Zr, often employed to reinforce aluminum or magnesium[50].

Carbon stands as an extraordinary element within the realm of nature. By skillfully manipulating its structure, a remarkable assortment of diverse structures spanning various length scales can be attained[22-24]. Graphene, carbon fibers, and nanotubes are just a few of the compounds made of carbon that have been produced via diligent research[51]. The multifaceted morphologies exhibited by these carbon-based materials, combined with their accessibility and potential for tailoring physical properties, have rendered them a focal point of heightened interest in modern materials science, overshadowing other elements[51,52].

Significantly, carbon fibers also display heightened temperature durability and inherent self-lubricating traits, thereby enhancing tribological attributes and toughness within aluminum-based composites reinforced with carbon fibers (CF-reinforced MMCs)[30-35,38-40]. Automobiles, airplanes, marine vessels, machinery parts, turbine blades, high-end sports goods, pressure vessels, the military industry, and civil engineering projects are just a few of the many industries that use carbon fibers because of their adaptability. The diverse range of properties possessed by carbon fibers has enabled their integration into various engineering realms including, aerospace, automobiles, nuclear engineering and the production of bearings, gears, heat sink and helicopter blades[22-24,36,37,42,45,51-54].

2.1 Manufacturing of Carbon Fibers

The fabrication of CFs from various precursor materials necessitates varying manufacturing methods. But the fundamental phases of the procedures exhibit shared characteristics. To elucidate the initial stride in the carbon fiber production, stabilizing precursor fibers within the temperature bracket of 200 to 400°C are executed within an air atmosphere to facilitate oxidation[55,56]. This stabilization process enhances the thermal stability of the fibers, serving to prevent their collapse at higher temperatures. Following stabilization, the precursor fibers proceed to the carbonization stage. During this process, the oxidized fibers are subjected to high temperatures (up to 1800°C) in an inert atmosphere to remove non-carbonaceous elements like oxygen, nitrogen and hydrogen[22-24,55,56]. This stage marks the transformation of the fibers into carbon fibers, although an additional step called graphitization is often employed to elevate carbon percentage content and longitudinal Young's modulus. In this step, fibers are subjected to temperatures exceeding 2000°C. Carbon fibers boasting a carbon content exceeding 99 wt.% are often referred to as graphite fibers. Commercially available carbon fibers subsequently undergo surface treatment[57] to enhance surface properties. Despite carbon fibers being among the most robust types of fibers, their strength values still fall short of 10% of the theoretical strength attributed to a C-C bond[57,58].

A variety of precursor materials can be utilized for crafting carbon fibers, subjected to controlled heat treatment while under tension in a process involving the following methods: carbonization and stabilization[22-24,55-58].

One prominent precursor material is Poly-Acrylonitrile (PAN) based fiber, derived from acrylic fibers containing over 85% acrylonitrile. PAN-based fibers are renowned for their notable carbon yield and propensity for inter chain reactions. However, in their early development, the challenge revolved around spinning PAN polymer fibers because of its low degradation temperature and restricted solubility. Since the degradation temperature of PAN was below its melting point, the feasibility of melt-spinning PAN was restricted. Additionally, solubility challenges impeded the progress of wet spinning endeavors. Dimethyl Formamide (DMF) was considered as an appropriate solvent for Poly-Acrylonitrile[22-24,43-45,59,60].

Pitch-based precursor categorization is an alternate method that comes from a low molecular by-product of the petroleum or coal industries. Pitch was a leading contender for a carbon fiber precursor because of its remarkable 85% carbon production[43,44]. Pitch-based precursors' graphitic qualities impair the compression and transverse characteristics of the final carbon fibers[22-24,43-45,59,60].

3.0 Production Processes of MMCs Reinforced with Carbon Fiber (CF)

Much study has been done to investigate the possibility of using carbon fibers as reinforcement in Metal Matrix Composites (MMCs). These reinforced composites show promise in terms of reduced weight and enhanced strength[22-24,61].

The fibers can be reinforced using a variety of matrices[22-24,61,62]. Three general categories may be used to categorize the fabrication techniques used to create CF-MMCs: a) Solid-state processing b) Liquid-state processing c) Deposition processing[63].

3.1 Solid State Processing

The most popular technique for creating composites reinforced with carbon fibers is solid state processing. Using this method, the initial materials are processed without undergoing any phase changes and while they remain in their original solid state at room temperature. The bonding that results between the metallic matrix and CF is due to mutual diffusion happening at high temperatures and pressures in solid states that provides the foundation for the solid-state manufacturing of CF-MMCs[64-73].

3.1.1 Powder Metallurgy

A commonly employed technique for producing CNFs-MMCs through solid-state processing methods is powder metallurgy, recognized for its cost-effectiveness. This approach involves employing a ball mill to get a homogeneous dispersion of reinforcement in the matrices.

The creation of densely packed composites[64,74,75] would result from the ideal selection of ball and powder ratio, time of milling etc. The bonding between interfaces also plays a vital role in powder metallurgy technique[22-24,64,74-78].

3.2 Diffusion Bonding

To achieve lower temperature fabrication of CF-MMCs, specialized fabrication techniques employing purpose-designed tools such as dies and rams come to the fore. In these methods, a carbon fiber preform is typically fashioned through infiltration of carbon fibers into a polymer binder. This preform is then stacked with metal sheets by layering multiple preform layers with metal sheets[79]. Subsequently, the assembled layers undergo lower temperature compression at 20-30 MPa within a higher vacuum environment to stave off oxidation at bonding temperature of 450°C and bonding time of 30 mins. While the diffusion bonding process necessitates specialized tools, its advantage lies in the ability to operate at low temperatures, rendering it suitable for avoiding harsh consolidation environments[80].

3.3 Liquid-Based Processing

Liquid-based processing techniques offer multiple avenues for fabricating metal matrix composites, each varying in terms of simplicity, weight/complexity of the end-product and cost-effectiveness. Various processes such as casting, vacuum infiltration, among others, fall under the umbrella of liquid-based metallurgy methods. Stir liquid casting, squeeze casting and infiltration represent popular procedures in making carbon fiber-coated composites. These methods have the potential for increased fiber content, are more affordable, and need less time for processing. However, using high temperatures during the composite production process might lead to interfacial interactions besides wetting problems. The poor wetting in carbon fibers and metal in molten state, as well as potential reactions in between carbon and various metal elements during CF-MMC fabrication, pose challenges. Addressing these concerns often involves applying external pressure and protective coatings to carbon fiber surfaces. Density disparities between metal matrices and lightweight carbon fibers pose another hurdle in liquid state processing; carbon fibers may separate and float on the surface due to density differences[22-24,35,64,66-73].

Liquid state processing is generally suitable for fabricating complex geometries. Achieving homogeneous dispersion of carbon fibers via liquid state processing hinges on controlling processing parameters and surface modifications to enhance carbon fiber wetting by molten metal. Proper stirring of the molten metal and with suitable wetting agent inclusion homogeneous distribution of particles can be achieved with liquid metallurgy process. Friction Stir Processing (FSP) emerges as a cost-effective and straightforward manufacturing method that yields significant improvements in hardness[22-24,65,73,81,82].

3.4 Melt Stirring

The utilization of the melt stirring technique for the creation of MMCs has garnered significant attention from both industrial and academic circles. This approach stands out due to its straightforwardness and cost efficiency in contrast to alternative methods. In the melt stirring process, carbon fibers are uniformly blended into a molten matrix substance using conventional casting techniques (Figure 1). The inclusion of reinforcement material generally follows a specific molar ratio guideline. The process involves mechanical stirring at elevated temperatures lasting from 30 to 60 mins[22-24,64-73].

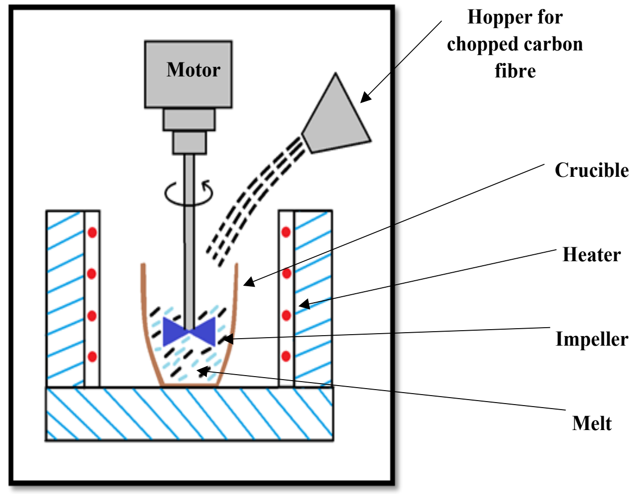

Figure 1. Preparation of CF reinforced MMCs using melt stirring technique.

In research by Lim *et al.*[82], a liquid-based method was used to investigate the effect of Carbon Nanofiber (CNF) dispersion on the mechanical properties of composites reinforced with CNFs. To improve the contact between aluminum and the carbon nanofibers, they used electroless plating to provide a copper coating on the CNFs' surface. The influence of carbon fiber aspect ratio on the fracture toughness of carbon fiber and composite was examined and found that the inclusion of carbon fiber improved the plane-strain fracture toughness of the aluminum alloy[83]. Researchers worked on a hybrid composite consisting of Al and Si alloy reinforced with carbon fibers and graphite rods[84]. They were successful in reducing the coefficient of friction under the considered load.

3.5 Slurry Casting

Slurry casting involves the utilization of the semi-solid technique, which operates at low freezing temperatures of the metallic matrix. Compo casting, a variant of slurry casting, entails the casting of composites utilizing rheo slurry within the temperature range between the solidus and liquidus points. This method involves melting an alloy over its liquidus point and then cooling it down gradually to the semi-solid region. Carbon fibers are added to the semi-solid slurry during the stirring process[85, 86]. This method's lower temperature by design reduces or completely eliminates the possibility of interfacial reactions and interface deterioration. The high matrix viscosity prevents fiber separation, which is a characteristic seen in other liquid processing techniques like melt stirring. Achieving a uniform dispersion of carbon fibers within the slurry casting process requires mechanical stirring and then followed by gravity casting conducted under reduced pressures [22-24,35,64,66-73,85,86].

3.6 Squeeze Casting

The squeeze casting process entails a series of steps, including the initial mold preheating, matrix melting, subsequent pouring into the mold, and the application of mold compression (Figure 2). The lower fixed mold half accommodates a reinforcement phase preform, encompassing particles or fibers. Typically placed within the matched die, this preform receives a precise volume of melted matrix material. High vacuum is created when 75-100 MPa of pressure is applied to the die. This technique proves adept at producing densely compacted yet relatively diminutive CF-MMC components. The utilization of squeeze casting yields opportunities for mitigating porosity and shrinkage, enhancing mechanical attributes and generating near-net shape items. However, it's noteworthy that excessive pressure during squeeze casting, aimed at achieving maximum infiltration thickness, could potentially inflict damage upon the preforms[87]. An alloy reinforced with alumina and carbon fiber was examined in in a research by Kaczmar *et al*[88]. Interestingly, the addition of carbon fiber increased the wear resistance of the composite by acting as a lubricant. Moreover, adding 10% Al_2O_3 resulted in a notable improvement in bending strength, which reached 100MPa at temperatures between 20 and 300°C. Hajjari *et al.*[81] conducted a separate investigation to investigate the impact of nickel coating on metal matrix composites made of aluminum alloy and continuous CF that were formed by the squeeze casting process at varying pressure levels.

3.7 Liquid Infiltration Processing

The liquid infiltration method involves passing the molten matrix through a fiber preform under elevated pressure until the matrix solidifies. Typically conducted within a pressurized inert atmosphere, this technique ensures effective capillary-driven infiltration due to the attraction between the CF preform and the molten matrix[22-24,64-73,85,86]. While pressure aids infiltration, excessive compression may hinder it. Successful matrix infiltration into the carbon fiber preform relies upon factors such as capillarity, fiber-matrix interactions, and solidification mechanisms[22-24,64-73,85,86]. To produce CF-MMCs, pressure infiltration casting at 720°C and 10

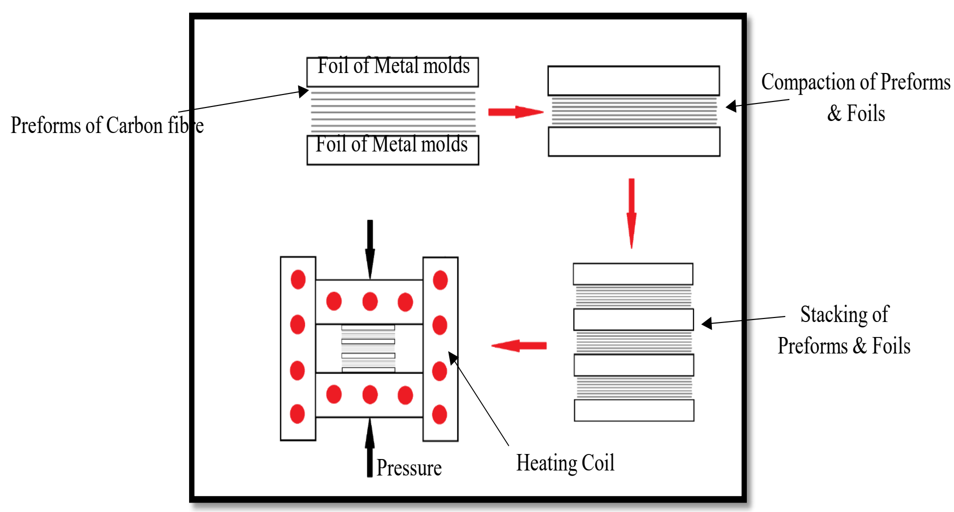

Figure 2. Squeeze casting process.

MPa was employed, offering precise composite shapes[89]. Notably, pressurized gas introduced the molten material into the preform. The metal matrix consisted of pure magnesium, with reinforcements like uncoated and TiN-coated carbon fibers. Lee *et al*.[90] investigated the effects of process parameters in Low-Pressure Infiltration (LPI) for producing unidirectional CF-Al Metal Matrix Composites (MMCs), focusing on Al_4C_3 formation. Al_4C_3 growth, particularly during cooling, adversely affected thermal conductivity. By carefully controlling the liquid-state aluminum temperature, significant suppression of Al_4C_3 growth was achieved, leading to near-theoretical longitudinal thermal conductivity.

3.8 Pressure Infiltration

The pressure infiltration technique exhibited notable effectiveness in the fabrication of high-performance Al-CFs composites[22-24,64-73,89]. For enhancing the attributes of Al-CFs composites synthesized through the pressure infiltration method can be achieved by employing the Z-pinning approach. To implement the Z-pinning, a Z Pin crafted from AISI 321 steel wire was employed, featuring varying diameters of 0.3 to 0.9 mm. Notably, the introduction of the Z Pin yielded substantial improvements. In the absence of a Z pin, the inter laminar shear strength for the Al-CFs composite measured 13.8 MPa. Impressively, the incorporation of Z Pins with diameters range of 0.3 to 0.9 mm resulted in inter laminar shear strength values of 23.8 MPa, 38.5 MPa and 45.9 MPa respectively[91-96].

3.9 Pressureless Infiltration

In this approach, manipulation of the atmospheric conditions and alloy composition permits the natural wetting and penetration of metallic alloy into reinforcement material beds or preforms, obviating the need for external pressure[92].

3.10 Deposition Processing

Two prevalent techniques for depositing materials, ion plating, and plasma spraying, found application in the creation of composites reinforced with carbon fibers. The said techniques were used across various studies to augment CF wettability and promote chemical bonding between CFs and the metal matrix.

3.10.1 Ion Plating

Carbon fibers are uniformly dispersed by air in a vacuum-sealed room with an inert argon environment during the ion plating process. An argon plasma is then produced by applying an appropriate voltage. Later, the metal is vaporized and applied to the fibers. Diffusion bonding and hot pressing are two other consolidation processes applied to the metal-coated fibers that result. For the manufacturing of CF-MMC, the ion plating method is quite similar to the spraying procedure. Spools of carbon fibers that are partially immersed in an electrolytic solution function as cathodes[97].

3.10.2 Plasma Spraying

Within the plasma spraying domain, methods like plasma spraying are used to deposit the matrix onto the surface of continuous fibers. Spooling continuous fibers is the first stage in the production of CF-MMCs. Next, either arc wire spraying with wires from the matrix material or plasma spraying with powders from the matrix are used. This process includes lamination, ultimate consolidation, applying the matrix by plasma or arc wire spraying, and winding carbon fibers. Plasma-sprayed carbon fibers can undergo consolidation via hot or cold isostatic pressing techniques. Metal-coated carbon fibers contribute to the formation of CF-MMCs, allowing for precise fiber orientation and volume ratios. A significant advantage of plasma spraying lies in its high plasma temperature, ranging from approximately 6000 to 15000K, rendering the technique suitable for processing high melting point materials[93,98-100].

4.0 Aluminium-Carbon Fiber (Al-CF) composites

Scholarly literature presents a series of insightful reviews and research studies focused on the remarkable potential of CF-MMCs. In a comprehensive examination by Soutis[101], the application prospects of these composites in aerospace and automotive contexts are explored. The review encompasses critical subjects including manufacturing techniques, mechanical characteristics, and the pivotal role of fiber-matrix bonding in influencing composite performance. The importance of robust interfacial bonding and judicious matrix alloy selection is underscored as essential to achieving optimal mechanical attributes within these composites. The assessment concludes by highlighting the promising viability of aluminum and carbon fiber combinations for lightweight structural components[102]. A focal point is the capacity of carbon fiber reinforcement to substantially bolster the wear resistance of aluminum composites, a pivotal facet for enhancing automotive component durability and overall performance. In a comprehensive review by the various authors[22-24,64-75, 103,104], a panoramic overview of CF-MMCs emerges. They discuss properties, manufacturing techniques, and an array of applications for these composites. The discussion encompasses various strengthening mechanisms, the significance of interfacial bonding, and the sway of processing parameters on resulting material traits. The authors accentuate the burgeoning utility of these composites within the aerospace, automotive, and sporting goods domains. Nonetheless, challenges related to fiber dispersion and judicious matrix alloy selection are also addressed. Authors[105-108] contribute an insightful review investigating the thermal, and tribological facets of carbon fiber-aluminum matrix composites. The authors expound upon advancements in manufacturing techniques, the intricacies of interfacial bonding mechanisms, and the considerable influence of fiber orientation on composite functionality. Moreover, potential applications such as automotive and aerospace components while grappling with challenges linked to processing efficiency and cost-effectiveness. Transitioning to specific explorations, a composite configuration is established by integrating Carbon-Fiber-Reinforced Thermoplastic (CFRTP) into an aluminum (A5052) matrix through the technique of friction lap joining[109]. Another investigation involves the laminate squeeze casting method to forge CF-reinforced Al6061 composite[110]. With CF content ranging from 7% to 14%, the composite showcases strong bonding between reinforcement and matrix, exemplified in elevated Vickers micro hardness. However, excessively high CF content (13.5%) is shown to compromise composite properties, attributed to reduced liquid flow and suboptimal interface attachment. Additionally, the multi pass Friction Stir Processing (FSP) technique is leveraged to synthesize Al-CF composites[65,73,111,112]. Remarkable outcomes, including a 13% enhancement in ultimate tensile strength and 18.6% improvement in elongation when compared to the base metal, are ascribed to abundant Geometrically Necessary Dislocations (GND's) induced by FSP and uniform reinforcement dispersion in the matrix[82]. In parallel, adhesive bonding is investigated to create CFR-Al alloy composites. Notable disparities in tensile shear strength between CFR configurations reveal the significant influence of fiber orientation on joint performance. Such explorations emphasize the role of processing techniques and reinforcement interactions in optimizing composite outcomes[22-24,57,64-73,108,109,113].

5.0 Conclusion and Future Prospects

The current review encapsulates on the growing allure of Al-CFs MMCs, an area that has captivated researchers in recent times. Substantial advancements in high-performance CFs underscore the potential for reinforcing metal matrices and enhancing composite efficacy. However, despite commendable research progress in this domain, certain unaddressed challenges for CF reinforced MMCs persist. Key factors such as intricate and costly processing methods, implications of size on strength, dimensional tolerances and impact strength warrant careful consideration. Astonishingly, only a limited array of processing methods are currently employed for crafting these composites. Unveiling novel, cost-effective processing techniques remains a priority, necessitating dedicated research efforts. The development of pioneering numerical and computer simulation techniques holds promise for propelling the field forward. Such simulations could usher in precise result predictions, effectively reducing processing time and expenditure. The aerospace, automotive, and petrochemical sectors are drawn to carbon fiber reinforced metal matrix composites because they have the potential to replace current unreinforced metals and alloys. Their increased resistance to wear and corrosion as well as their lower coefficient of friction make them attractive options for a variety of technical uses. Stir casting process is the most optimum method to prepare the metal matrix composites.

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