# A Review on Different Types of Hybrid Composite Materials with Different Matrix Proportions

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**Abstract -** A composite materials can be defined as amalgamation of the two or more materials that gives the better properties than those of individual components used alone. In contrast to the metallic alloys, each of the material retains its separate chemical, physical, and mechanical properties. The two constituents are reinforcement and a matrix. The advantages of the composite materials are of having a high tensile strength and toughness combined with the low density when it has been compared with the classical materials. Micromechanical methodology is found to be fit for the analysis of composite materials because it studies the volume proportions of the constituents for the desired lamina toughness and strength. It is establish that the manufacturing processes is responsible of many faults which may arise in the fibers, matrix and lamina. These defects, if they exist include misalignment of the fibers, cracks in matrix, non-uniform spreading of the fibers in the matrix, cavities in fibers and matrix, delaminated regions, and initial stress in the lamina as a result of its manufacture and further treatment. The above stated defects have a tendency to propagate as the lamina is loaded and causing an accelerated rate of failure. The experimental and theoretical results in this case tend to differ. Therefore, due to the limitations in the idealization of the lamina components, the properties estimated should be proved with experimentally.

***Key Words***: Hybrid polymer matrix composites, natural fibers, Aluminum oxide, silicon carbide, aluminium matrix composites.

## 1. INTRODUCTION

Composite materials are first considered as the structural materials a slight more than the half a century before. From that time to now, they have received the increasing attention in all aspects of material science technology, manufacturing techniques, and theoretical investigation. Since all materials are composites of dissimilar sub units are examined at close enough details. But in latest materials engineering technology, the term usually states to a Matrix material that has to be reinforced with fibers. For case, the term "FRP" which refers to Fiber Reinforced Plastic typically indicates a thermosetting polyester matrix containing glass fibers, and this particular composite has the lion's share of today commercial market. Many composites used today are at the leading edge of materials technology, with performance and costs proper to ultra-demanding applications such as space craft engineering. Aluminum (Al) and its alloys have been attracted towards more attention as base metals in the polymer matrix mixtures. They are under Serious consideration to replace the conventional materials for structural applications such as those in the aeronautical, transportation, defense, automotive (pistons, cylinder liners, bearings) and sports industries because of their superior properties this particular composite has the lion's share of today commercial market. They are under Serious consideration to replace the conventional materials for structural applications such as those in the aeronautical, transportation, defense, automotive (pistons, cylinder liners, bearings) and sports industries because of their superior properties [1].The most commonly used reinforcements are Aluminum oxide ($Al_2O_3$) and Silicon Carbide (SiC). Aluminum matrix Composites (AMC) reinforced with SiC are preferred due to their high wear resistance, high thermal conductivity, low thermal expansion and other improved mechanical properties. The addition of SiC in Aluminum improves properties like hardness, Tensile strength and density. [2] Investigated the behavior of the unreinforced 6061 aluminum alloy and short fiber reinforced alloy.

## 2. MATERIALS

### 2.1 Glass Fiber

Glass fiber is a material that contains extremely fine fibers of glass. It has a less weight, awfully strong, and vigorous. The glass fibers are prepared when thin strands of silica glass are extruded into many fibers with small diameters. Its majority strength and weight properties are also very satisfactory when compared to the metals, and it can be certainly made using molding processes. This is used as the reinforcing agent for mixtures to form a very tough and light fiber reinforced polymer (FRP) composite material.

### 2.2 Epoxy Resin

Epoxy resin is used to give great binding properties between the fiber layers. The Epoxy resin used is LY556 and Hardener (HY 951) and is prepared to improve the interfacial bond and impart strength to the composite materials. A resin and hardener mixture of 10:1 is used to obtain finest matrix composition.

### 2.3 Matrix

Aluminum, magnesium and copper mostly investigated matrix materials due to its high strength to weight ratio. Aluminum and magnesium have earmarked their slot in the

MMCs due to low density and machinability. The Elements like silicon, zinc, magnesium, boron, and copper are gifted with the suitable solubility which makes them feasible to be used as the key alloying components. Particle size having significant role in the MMCs. Grain refinement can reduce the thermal expansion, hence strength of the matrix increased. Strength of the matrix enhances with decrease in grain size but the overall output not improved significantly. Shape, size and volume fraction of the reinforcement also have an important role in strength of the composite.

## 2.4 Hybrid

Hybrid MMCs were formed by reinforcing the base matrix with more than one reinforcement having different properties. The composites which have a combination of two or more reinforcement of particles are capable of enhancing the mechanical characteristic properties of the composite materials [13]. The performance of hybrid composites is a collective effect of the individual constituents in which there is a better balance between the inbuilt advantages and disadvantages. The Silicon carbide material (SiC), aluminum ($Al_2O_3$), boron carbide material ($B_4C$),tungsten carbide (WC), graphite (Gr), single or multi types of carbon nanotubes (CNT) and silica ($SiO_2$) and are a few of the reinforcements which are used, but silicon carbide and aluminum are characteristically used compared to other reinforcing composite materials.

## 3. LITERATURE REVIEW

Hybrid composites are materials which are made by combining two or more different types of fiber matrix.

In this paper we works at the growth of hybrid mixed composites with different matrix concentration. Intended for the processing of lower-limb prosthesis. This method used for improving the matrix-dominant properties contained on the incorporation of graphite platelets as a filler material in the epoxy gum. Previous research by other authors e.g. (Cho et al. 2007, Ozerol et al. 2015) has shown that the matrix-dominated mechanical properties of fiber/polymer matrix composites can be improved incorporating fillers, with improvement depending on the processing method and the type, surface condition, concentration and dispersion of the filler elements. The addition of fillers to an epoxy matrix ensures the maintenance of adequate mechanical and tribological properties, together with a direct cost reduction due to the lower consumption of resin material (Suresha et al. 2007).

*Madhusudhan T, et al* [4] made the Comparison of Hybrid Composite materials with Different types of Filler Materials has been used with the different amounts. He examine the hybrid composites with 2 different fiber materials and tungsten carbide as the filler material has higher tensile strength and hardness when compared to the material with 3 fiber material and Silica carbide is used as the filler material. The filled Sic with hybrid material with aramid-glass-carbon fibers exhibited higher strength than hybrid material with aramid and glass fiber filled with WC, this is owing to resistance of the materials. Hence the material is biodegradable it can be used in Making any of the household applications for under water applications.

*Madhusudhan T, et al [5]* Mechanical Characterization of Jute and Rubber Particles Reinforced Epoxy Polymer Composites. In this tensile and flexural properties are influenced by the fiber composition than the rubber particulate. The combination of these materials in composites can be used as alternative in any synthetic fiber filled polymer composites.

*Madhusudhan T, et al [6]* Investigation on the Wear Resistance Behavior of Silica carbide Filled hybrid Composites. The polymer composites with 10% sic show least wear loss in all combinations, the lowest wear loss achieved in glass rubber epoxy with 10% Sic.

*Madhusudhan T, et al [7]* Investigation and Study on Wear Behavior of Sic Filled Hybrid Composites Using the Taguchi Method. In This the Tested Filled Hybrid Composites With 10% Sic by weight shows a better tribological properties. By the method of the taguchi wear test on the polymer composites the material influences the wear character, load on the materials, and speed rotation of the disc. Taguchi material analysis is best suited to minimize the number experiments.

*VijayaRamnath et al. [4, 5]* studied the mechanical behavior of glass fiber and concluded that the polyester resin composite shows higher shear strength and the enhanced performance of stiffness and strength will be satisfied at 12mm thick GFRP.

*NarayanaMurty et al [6]* studied the hot working characteristics of SiC and $Al_2O_3$ particulate reinforced polymer matrix composites. The author suggested from the productivity viewpoint that a high strain rate region in which high values of mass and efficiency are present should be selected for majority working operations and the lower strain rate regions for secondary polymer working operations.

*Park et al. [7]* investigated the effect of $Al_2O_3$ in Aluminum for volume fractions varying from 5-30% and found that the increase in volume fraction of $Al_2O_3$ decreased the fracture toughness of the MMC. This is owing to decrease in the inter-particle spacing between the nucleated micro cavities.

*Park et al. [8]* investigated the high cycle fatigue behavior of 6061 Al-Mg-Si alloy reinforced $Al_2O_3$ microspheres with the varying volume fraction ranging between 5% and 30%. The addition of dry solids such as organic fillers in polymer matrices could offer potential advantages in sustainability by using raw materials from renewable resources. It offers the possibility of developing suitable materials according to the destination or use, reducing costs and improving the mechanical strength characteristics. Moreover, the lingo cellulosic materials have additional advantages such as its low density, do not require complex equipment to process, not cause abrasion during processing and are abundant T serki et al. (2005).

*Niranjan Raja et al*. showed and analysis of Woven roving composites laminates and studied the properties and the performances. The result shows that plain specimen is having more strength followed by circular hole and then rectangular hole.

*Tjong et al. [9]* compared the properties of two aluminum metal matrix composites, Al–$B_2O_3$–$TiO_2$ system and Al–B–$TiO_2$ system. It was found that the reactive hot pressing of the composites resulted in the formation of ceramic $Al_2O_3$ and $TiB_2$ particulates as well as coarse inter metallic $Al_3Ti$ blocks. Al–$B_2O_3$–$TiO_2$ had more fatigue strength than Al–B–$TiO_2$.

*Kok [10]* investigated the $Al_2O_3$ particle reinforced 2024 Al alloy composites by vortex method and studied their mechanical strength properties and found the optimum conditions of the production process with a pouring temperature of 700°C, preheated mould temperature of 550°C, stirring speed of 900rev/min, particle addition rate of 5g/min and with a applied pressure of 6MPa. The wettability and the bonding between Al alloy/$Al_2O_3$ particles were improved.

*Boopathi et al. [19]* has studied the microstructures of aluminum alloys (Al 2024) reinforced with the different configurations of fly ash, Silica carbide and their combinations. It has been observed that the particles were randomly distributed in single reinforced composites and segregation of particles was clearly visible. This was attributed to the gravity-regulated separation of the particles in melt. But, the micrographs of Al/SiC/fly ash hybrid composites indicate uniform distribution of particles at numerous solicitations.

*Prasad and Shobha [23*] has studied and observed the microstructural appearances of the hybrid composites materials reinforced by Silica carbide and rice husk ash (RHA) atoms. The uniform distribution of reinforcing particles was revealed during the examination. The presence of RHA and SiC particles was also confirmed in the micrographs of hybrid composites.

*Dhanasekaran and Gnanamoorthy [15]* studied the tribological properties of Fe–Cu–C alloy containing $MoS_2$ particles, and it was observed that the composites exhibit better tribological properties up to 3 vol. % of $MoS_2$ particles addition. However, the composites exhibit poor tribological properties as the concentration of $MoS_2$ particles is increased to 5 vol. %.

*Venkateshwaran et al. [4]* studied the mechanical properties such as tensile strength, flexural strength, impact strength and water absorption rate of sisal and banana fibers reinforced epoxy composite materials. They have observed that there is the significant improvement in mechanical strength and reduction in water absorption rate while hybridizing the sisal fiber up to 50% by weight with banana fiber reinforced epoxy composites. The banana and GFRP composites are have a good tensile properties with smallest deflection when compared to the flax and GFRP composites [5].The banana and flax fiber reinforced composites holds the more flexural and impression strengths of the composite materials when compared to the flax and glass fiber reinforced polymer composites.

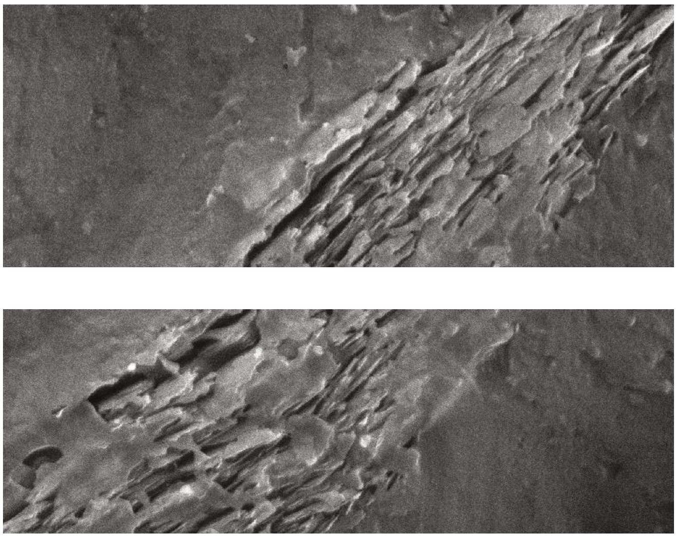
*Yuanjian and Isaac [11]* have investigated the impact and fatigue behavior of non-woven hemp fiber composites which is reinforced with polyester and found that there is the remarkable improvement in such properties.

*Banerjee et al. [18]* have conducted the micromechanics analysis of hybrid composites by using FEA software (ABAQUS/CAE 6.9-2). The different hybrid laminates are prepared by using short carbon fibers and glass fibers which is reinforced with polypropylene. In this study, the elastic constant and strength properties have evaluated by using analytical formula and the results are compared with FEA results.

## 4. MICROSTRUCTURAL FEATURES

The microstructural features of the composites are produced with the filler materials of different concentration of graphite/epoxy materials show uniform microstructures for added graphite amounts up to 12.5 wt%. The graphite platelets are well dispersed in the epoxy matrix. The frequency and the size of the agglomerates increase with increasing in the graphite material contents. The graphite/epoxy interfacial adhesion looks to be somewhat weak as shown in the figure (Fig. 4b, arrow).


(a)



*(b)*

Fig.4.1 Microstructure of produced materials: (a) graphite dispersion in RG 5% sample; (b) graphite/epoxy interface in RG 12.5% sample

For graphite contents above 12.5 wt% sample porosity significantly increases. In fact, these samples showed high viscosity during resin processing, which made air elimination during mixing and casting more difficult and resulted in extensive voids presence in the 15 and 30 wt%-graphite samples after setting.

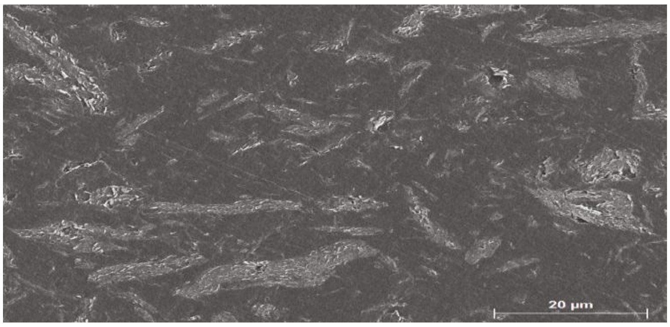



Fig.4.2 Epoxy containing 30 wt%-graphite low magnification SEM image of sample microstructure

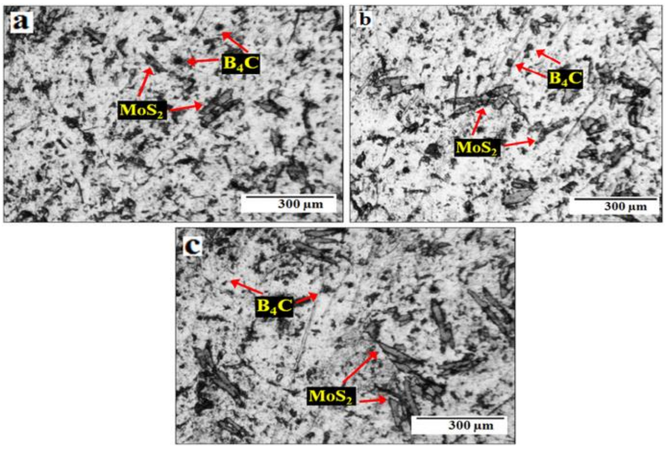



Fig.4.3Metallography of the hybrid composites: (a) AA6061-10 wt. % B4C–2.5 wt. % MoS2, (b) AA6061-10 wt. % B4C–5 wt. % MoS2 and (c) AA6061-10 wt. % B4C–7.5 wt. % MoS2

Fig.4.3 shows the effect of MoS2 addition on the hardness of the hybrid composites. It is evident that the hardness of the mono composite is higher than that of the hybrid composites. The hardness of the hybrid composites decreases gradually with increase in MoS2 particles addition.

The decrease in hardness with the increase in MoS2 Particles addition is attributed to the lubrication property of the MoS2 particles which facilitates ease movement of grains along the slip planes due to which the specimen deforms easily under the indenter of the hardness tester

## 5. CONCLUSIONS

The following are have the some of the features have been concluded based on the review

- The amalgamation of the two or more different amounts material makes the material strength hard and with high tensile strength and also processing a high roughness and becomes versatile material in the present engineering technology.
- In this work Al2O3 and Silica carbide reinforced composites using the epoxy and polyester resin is produced with resin transfer method. Their mechanical strength properties like tensile strength, shear strength, impact, compressive strength, hardness and biaxial strength are inspected by using the Arcan fixture.
- The mechanical properties of natural fibers reinforced composites are not very satisfactory full filling the requirements, but with the mixed proportion of the hybrid composite materials by inserting the micron and nono sized particles to improve both the mechanical and tribological properties of composites materials.
- The Graphite-reinforced epoxy resin achieved results shows that the different percent of 7.5, 10 and 11.5 wt%-graphite results the best steadiness of mechanical (modulus, strength, strain) properties in the composite materials, since scattering of graphite platelets is more identical. Eliminating the matrix porosity is required for increased mechanical performance. The same trends result shows that when carbon fiber has introduced into the reinforcement phase.
- The stiffness of the mixed composites decreases uneventfully with the increase in the addition of the MoS2 particles. The hybrid composites become more easily deformable with the increase in MoS2 particles concentration leading to a decrease in hardness of the composite materials.
- The fracture toughness of the hybrid composites is decreased with increase in MoS2 particles addition. Fractograph of 7.5 wt. % MoS2 hybrid composite

reveals segregation of reinforcement particles which enhances the fracture process.

- Increasing the concentration of the addition of the filler content tends to increase the modulus and hardness but there is a decreases tensile strength of composite.
- By adding SiC particles into jute/epoxy composites. This helps to make better tribological properties for different applications.
- Combination of the different composite material with different filler materials with different proportions possessing a high characteristics of tensile strength, good corrosive resistance, eco-friendly to the environment and high strength with low cost compare to other materials.

## REFERENCES

[1] Daniel B. Miracle and Steven L. Donaldson, "Introduction to composites", *ASM Hand book of composite materials*, volume-21.
[2] Tamer Ozben, ErolKilickap, OrhanÇakir, "Investigation of mechanical and machinability properties of SiC particle reinforced Al-MMC". *Journal of materials processing technology* 198 (2008) 220-225.
[3] D. Sujan, Z. Oo, M.E. Rahman, M.A. Maleque, C.K. Tan, "Physio-mechanical properties of Aluminum metal matrix composites reinforced with Al2O3 and SiC". *International journal of Engineering and Applied Sciences* 6 2012.
[4] Suresha, B., Chandramohan, G., Renukappa, N.M., Siddaramaiah, 2007. Mechanical and Tribological Properties of Glass–Epoxy Composites with and Without Graphite Particulate Filler. Journal of Applied Polymer Science 103, 2472–2480.
[5] Ha. Yu, M.L. Longana, Y. Swolfs, M.R. Wisnom, K.D. Potter, Hybrid effect of carbon/glass composites as a function of the strength distribution of aligned short carbon fibers, in Proceedings of ECCM17, 26e30th June 2016. Munich, Germany.
[6] Mitrovic´ S, Babic´ M, Stojanovic´ B, Miloradovic´ N, Pantic´ M, Dzuni ˇ c´ D. Tribological potential of hybrid composites based on zinc and aluminum alloys reinforced with SiC and graphite particles. Tribol Ind 2012; 34: 177–85
[7] Suresha S, Sridhara BK. Wear characteristics of hybrid aluminum matrix composites reinforced with graphite and silicon carbide particulates. Compos Sci Technol 2010; 70:1652–9.
[8] Kök M. Abrasive wear of Al2O3 particle reinforced 2024 aluminum alloy composites fabricated by vortex method. Composites a 2006; 37:457–64.
[9] Siva Prasad D, Shobha Ch, Ramaniah N. Investigations on mechanical properties of aluminum hybrid composites. J Mater Res Technol 2014; 3(1):79–85
[10] Gibson PR, Clegg AJ, Das AA. Wear of cast Al–Si alloys containing graphite. Wear 1984; 95:193–8
[11] Alanemea KK, Ademilua BO, Bodunrin MO. Mechanical properties and corrosion behavior of aluminum hybrid composites reinforced with silicon carbide and bamboo leaf Ash. Tribol Ind 2013; 35(1):25–35.
[12] Thakur SK, Dhindaw BK. The impact of interfacial features between the SiCp and Mg/Al metal matrix on wear, coefficient of friction and micro hardness structures. Wear 2001; 247(2):191–201.
[13] Madhusudhan T, SenthiL Kumar M. Comparison of Hybrid Composites with Different Filler Material. International Journal of Engineering Research and General Science Volume 4, Issue 2, March-April, 2016, ISSN 2091-2730.
[14] Madhusudhan T, SenthiL Kumar M. the Mechanical Characterization of Jute and the Rubber Particles Reinforced Epoxy Polymer Composites. IOSR Journal of Pharmacy, (e)-ISSN: 2250-3013, (p)-ISSN: 2319-4219, Volume 6, Issue 12 Version. 1 (Dec 2016), PP. 23-27
[15] T. Madhusudhan, Dr. M. Senthil Kumar, Investigation on Wear Resistance Behavior of Sic Filled hybrid Composites. International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 2, February 2017, pp. 82–92 Article ID: IJMET_08_02_010.
[16] Madhusudhan T and M. SenthiL Kumar. The Experimental Study on the Wear Behavior of Silica carbide Filled Hybrid Composites Using the Taguchi Method. International Journal of Mechanical Engineering and Technology (IJMET), Volume 8, Issue 2, February 2017, pp. 271–277 Article ID: IJMET_08_02_03

## BIOGRAPHIES

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