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Experimental and Testing of Kevlar Carbon and E Glass with 5grams Graphite Using Handlay Up Technique

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Abstract
Nowadays material technologies are playing major role for the development of products in various fields. Many researchers are searching for structural materials of high strength, less weight and low cost. In generally strong materials are relatively dense and light materials have less strength. In order to achieve high strength and less weight, we go for composite materials. This Project thesis deals with the various hybrid composites Made of carbon fiber and Kevlar fiber with E glass using various Hybrids using 5 grams of Graphite powder in all materials which are fabricated by hand lay-up method using an Epoxy resin and a hardener. The properties of this hybrid composite are determined by testing like Tensile, flexural, impact, and hardness which are evaluated experimentally according to ASTM standards.

Keywords: *Testing, Graphite, Handlay.*

1. Introduction

1.1. Introduction to Composite Materials

Composite materials have transformed contemporary engineering by providing exceptional strength, reduced weight, and increased durability. Unlike conventional materials like metals and ceramics, composites are designed by combining two or more different components to enhance their mechanical and physical performance.

1.2. Types of Composite Materials

- **Polymer Matrix Composites (PMCs):** These materials feature a polymer-based matrix—such as epoxy, polyester, or vinyl ester—reinforced with fibers like carbon, glass, or natural fibers. Known for their lightweight and high impact resistance, PMCs are extensively utilized in aerospace, automotive industries, and sports equipment.
- **Metal Matrix Composites (MMCs):** Made with a metal matrix—such as aluminum, titanium, or magnesium—reinforced with ceramic or metallic particles, MMCs provide outstanding thermal stability and strength. They are ideal for high-temperature applications, including aircraft engines and automotive braking systems.

1.3. Advantages of Composite Materials

- Exceptional Strength-to-Weight Ratio: Composites deliver high strength while remaining much lighter than conventional materials such as steel or aluminum.
- Resistance to Corrosion and Chemicals: Unlike metals, composites are highly resistant to environmental and chemical damage, making them well-suited for use in marine and aerospace settings.

1.4. Applications of Composite Materials

1.4.1. Aerospace Industry

Composite materials are essential in modern aerospace engineering, offering significant weight reduction without compromising structural strength

1.4.2. Marine Industry

The marine environment requires materials that can

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withstand corrosion and resist moisture absorption. Composite materials meet these demands and are used in a variety of marine applications, including:

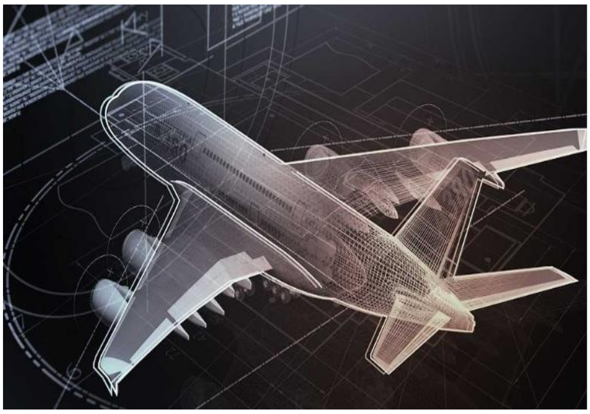

Figure 1 Aero-Space Application

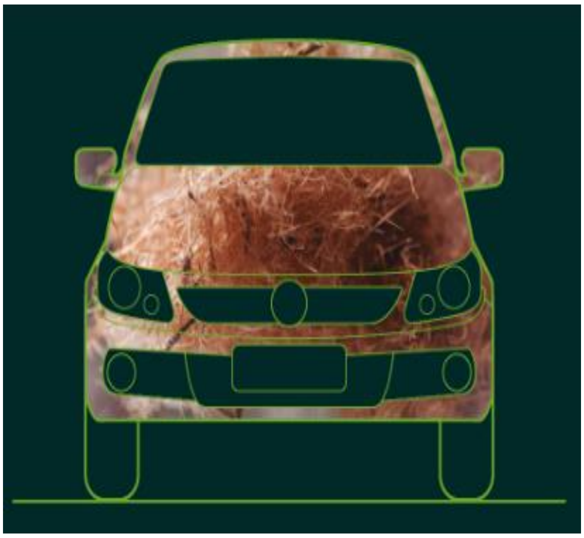

Figure 2 Automobile Application of Fibers

- **Ship and Boat Hulls:** Fiberglass-reinforced composites are commonly employed in yachts, submarines, and naval vessels, providing lightweight and durable construction.
- **Offshore Structures:** Platforms such as oil rigs and floating wind turbines rely on composites for their ability to endure extreme marine conditions without deteriorating.
- **Propellers and Rudders:** Composite components offer reduced weight, superior corrosion resistance, and lower cavitation, enhancing overall performance.

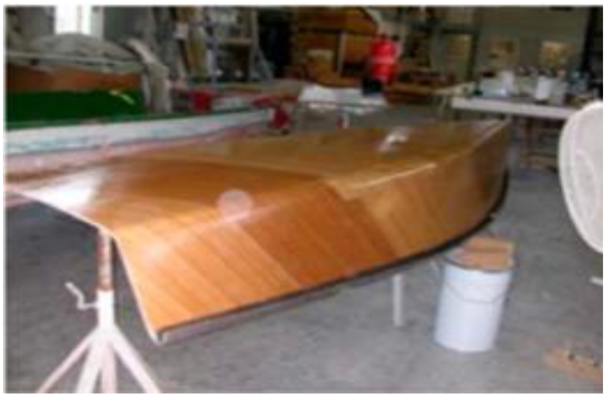

Figure 3 Marine Application of Fibers

1.4.3. Biomedical Applications

- Composite materials are revolutionizing the medical and healthcare industry by providing biocompatibility, strength, and adaptability. Notable applications include:
- **Prosthetics and Implants:** Carbon fiber and polymer composites are utilized to develop lightweight, durable, and flexible prosthetic limbs that closely replicate natural motion.

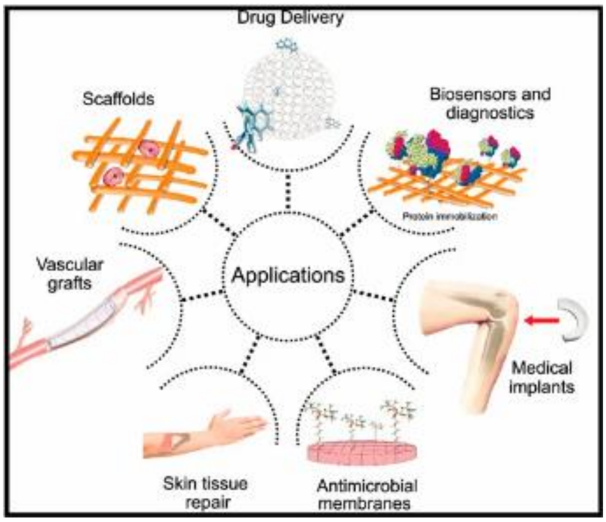

Figure 4 Bio Medical Application of Fibers

1.4.4. Defense & Military Applications

The defense industry depends on composite materials for a range of advanced technological applications, including:

- **Bulletproof Vests and Helmets:** Composites made from Kevlar and aramid fibers offer lightweight, high-strength ballistic protection

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for military personnel.

- **Enhanced Maneuverability and Payload Capacity:** The use of composites in military vehicles and aircraft helps reduce weight, improving agility and allowing for greater payload efficiency**.**

Figure 5 Fiber Helmet for Defense Applications

1.4.5. Alloy Wheel

Alloy wheel is a fundamental device that facilitates the efficient movement of objects across a surface, especially when a force presses the object against that surface. Early wheels were solid wooden disks with a central hole for an axle. However, cutting a horizontal slice from a tree trunk was unsuitable due to its lack of structural strength under load; instead, curved segments from longitudinal boards were used to create more durable wheels. The later invention of the spoked wheel marked a significant advancement, enabling the development of lighter and faster vehicles.

Automobile wheels, in particular, must meet several key requirements to ensure safety, performance, and durability.

2. Literature Review

[1] C.H. Nam, C.J. Halbach et al., "Stab Resistance of Shear Thickening Fluid (STF)-Treated Fabrics": This study focuses on developing stab-resistant materials using a combination of shear thickening fluid (STF) and Kevlar fibers. A suspension of silica in ethylene glycol was prepared and evaluated using a rheometer. The results showed that the STF exhibited a reversible liquid-to-solid transition under specific shear conditions. Kevlar fabrics were treated with STF using a one-dip-one-nip method, and their mechanical and stab-resistant properties were tested. The findings demonstrated that STF treatment significantly enhanced Kevlar's resistance to spike threats, thereby improving its overall safety performance. [2] Taewook Kang et al., "Preparation and Properties of Fumed Silica/Kevlar Composite Fabrics for Stab-Resistant Applications": This research explored the use of a fumed silica/ethylene glycol STF to coat Kevlar fabrics, aiming to boost their stab resistance. The treated fabrics showed substantial improvements in puncture resistance, particularly under high-speed impacts. Importantly, the flexibility of the fabric remained unaffected. The results indicated that fumed silica/Kevlar composites are highly suitable for body armor applications. The study also investigated composites made from Kevlar (poly(p-phenylene terephthalamide)) and Santoprene, comparing unmodified and modified Kevlar fibers. The modified Kevlar showed superior performance in composite applications. [3] Rajasundar Chandran et al., "Hybrid Processing of Thermoplastic-Based Multilaterals": This investigation assessed the reinforcing effects of Kevlar fibers in Santoprene composites. Unmodified Kevlar improved certain properties such as low strain modulus and tensile strength, but it significantly reduced elongation at break. To address this, the Kevlar surface was modified using maleic anhydride-grafted polypropylene (MA-g-PP). The modified Kevlar enhanced interfacial bonding with the matrix, resulting in improved stress distribution and overall mechanical performance, while minimizing previous drawbacks.

3. Project Overview and Methodology

3.1.Objectives

Following are the objectives that have been outlined:

Step 1: Preparation of Laminates

- **Base Material:** Epoxy resin is selected as the base material for the laminates because of its superior strength, excellent adhesion, and strong chemical resistance.
- **Reinforcement:** The laminates are reinforced with E-glass fibers, Kevlar, and carbon fibers, along with 5 grams of graphite. These reinforcement materials enhance the strength and stiffness of the laminates. E-glass fibers, Kevlar, and carbon fibers are well-known for

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their high tensile strength and impact resistance. Together, they provide an optimal balance of strength, stiffness, and cost efficiency. Carbon fibers additionally improve reinforcement by helping to evenly distribute stress throughout the laminate.

3.2.Materials

Among various types of resins and hardeners, Epoxy LY556 and hardener HY951 were selected for this study. The materials used to fabricate the specimens include carbon fiber, E-glass, and graphite powder, which were combined in different ratios and configurations. Six distinct composite samples were prepared and tested for impact strength, tensile strength, and flexural strength.In India, there is a wide variety of natural fiber resources derived from plants and trees, including both cultivated and wild species such as creepers and forest trees. It is well established that materials with a fibrous structure tend to have greater strength than those in bulk form. Therefore, these strong natural fibers are often utilized for reinforcement. Specifically, pineapple and Agave Americana fibers are abundantly available in India and have been traditionally used for medicinal purposes. However, the commercial use of these fibers is still limited compared to other fibers. This study aims to explore the potential of incorporating these natural fibers into new composite blends for load-bearing applications. The primary goal of using natural fibers is to enhance composite strength. Additionally, many natural fiber composites tend to be more cost-effective than those reinforced with synthetic fibers.

3.3.Graphite Powder

Figure 6 Graphite Powder

3.4.Kevlar

Kevlar is widely used in applications such as bicycle tires, racing sails, and bulletproof vests, primarily because of its exceptional tensile strength-to-weight ratio—being five times stronger than steel by this measure. It is also employed in modern marching drumheads, which require high impact resistance. Synthetic fibers are often used to enhance the properties of natural animal and plant fibers. Among the hundreds of synthetic fiber types, polyester and nylon are the most common. Historically, most research on woven textile composites has focused on synthetic fibers rather than natural ones. Synthetic fibers offer several advantages, including low moisture absorption, thermoplasticity, abrasion resistance, and easy availability. Compared to natural fibers, synthetic fibers tend to be more durable, stronger, easier to care for, and machine washable. (Figure 6)

Figure 7 Kevlar Fiber

3.5.Carbon Fiber

Carbon fiber is a material made up of thin, strong crystalline filaments of carbon atoms bonded into long chains. It offers numerous advantages due to its exceptional stiffness, strength, and lightweight nature. Carbon fiber is widely used in manufacturing high-performance building materials. This material is available in various forms, including yarns, unidirectional sheets, woven fabrics, braids, and more. These raw forms serve as the foundation for producing carbon fiber composite components used across diverse industries. (Figure 8)

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Figure 8 Carbon Fiber

3.6.E Glass

This product is well-suited for compression-molded laminates as well as electrical and non-electrical laminates. It is compatible with pultrusion, infusion, and injection techniques such as RTM, S-RIM, and matched die molding. It features an insoluble binding agent effective with unsaturated polyester, epoxy, and polyurethane resin systems, both filled and unfilled. Available in powder or emulsion mat forms, it offers excellent control over stiffness, flexibility, handling, and tensile strength. (Figure 9)

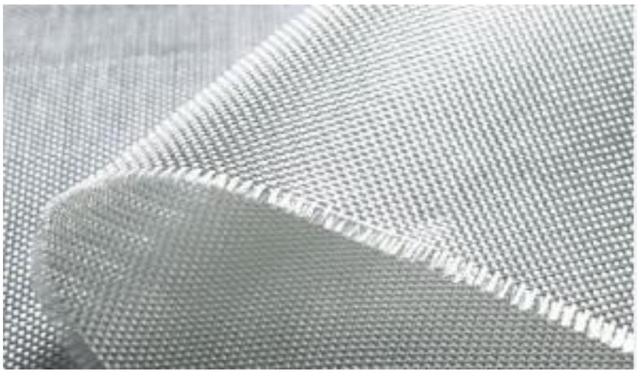

Figure 9 E Glass Fiber

4. Fabrication of Composite Specimens

4.1.Hand Layup Process

The hand lay-up technique is the simplest and most cost-effective method for processing composites, requiring minimal infrastructure. Mechanical properties of fiber-resin composites are tested following the ASTM D790M-86 standard procedure. To prepare the mold, a smooth clear film is used with double-sided tape applied according to the required dimensions. The mold surface is then created by placing the double-sided tape onto the clear film. (Figure 10)

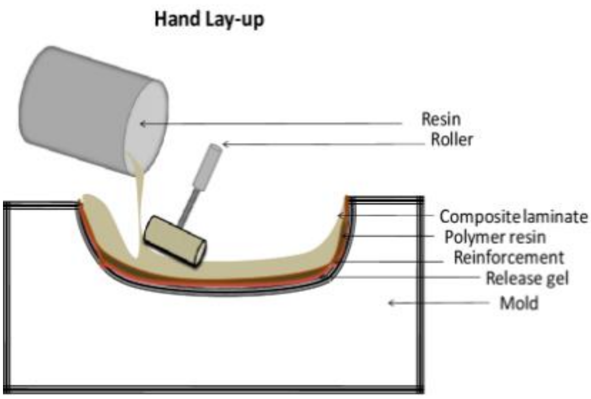

Figure 10 Hand Layup Process

Figure 11 Various Materials Used for Specimens (Kevlar, Carbon, E-Glass, Graphite Powder, Hardner, Epoxy)

5. Testing Experimental Setup

5.1.Tensile Testing of Composites

A 2-ton capacity electronic tensometer, model METM 2000 ER-1 (shown in Figure 3.13 and Plate II-18), is used to measure the elasticity of composite materials. The tensometer's capacity can be adjusted using load cells rated at 20 kg, 200 kg, or 2 tons; for testing composite specimens, the 2-ton load cell is employed.

6. Results and Discussion

6.1.Mechanical Characteristics of Composites

The properties of epoxy hybrid composites reinforced with Kevlar, carbon fiber, E-glass, and their combinations—Kevlar/carbon fiber, Kevlar/carbon fiber/E-glass, Kevlar/E-glass, and carbon fiber/E-glass—along with 5 grams of graphite powder in all mixtures, are presented in Table 6.1 below. Each composite was tested individually for the various properties. Detailed descriptions of the composite

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fabrication process and the conducted tests are provided in the previous chapter. (Figure 12)

S.NO	COMPOSITE	TENSILE TEST(MPa)		FLEXURAL TEST(MPa)		IMPACT TEST	HARDNESS NUMBER
		LOAD(N)	ELONGATION(mm)	LOAD(N)	ELONGATION(mm)	(J)	
1	KEVLAR	8340	5.5	340	8.2	2.7	100.65
2	E GLASS	5690	3.9	780	6.8	4.9	62.41
3	CARBON FIBER	6550	4.1	1250	8.8	6.4	94.95
4	KEVLAR/E GLASS	9470	6.2	840	7.7	3.8	59.51
5	KEVLAR/CARBON	10720	6.1	1240	5.4	6.9	130
6	E GLASS/CARBON	12530	5.7	470	4.2	6.2	129.22
7	KEVLAR/E GLASS/CARBON	12910	6.3	1280	9.3	5.8	159.15

Figure 12 Specimens Testing Results

6.2.Tensile Strength

S.NO	COMPOSITE	TENSILE TEST(MPa)			
		LOAD(N)	ELONGATION(mm)	TENSILE STRENGTH(MPA)	% OF ELONGATION
1	KEVLAR	6850	4.2	0.94	2.56
2	E GLASS	8800	4.4	1.21	2.68
3	CARBON FIBER	16320	5.9	2.24	3.59
4	KEVLAR/E GLASS	9500	5.1	1.3	3.1
5	KEVLAR/CARBON	16740	7.1	2.3	4.32
6	E GLASS/CARBON	14870	6.9	2.04	4.2
7	KEVLAR/E GLASS/CARBON	16010	5.9	2.2	3.59

Figure 13 Tensile Testing Results for 7 Composites

Following the successful completion of tensile strength testing, the Kevlar/Carbon fiber composite with 5 grams of graphite powder demonstrated the highest strength, reaching a maximum load of 16,740 N. (Figure 14) [4]

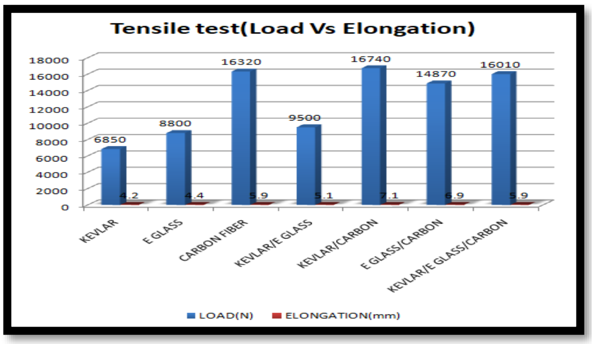

Figure 14 Graph 1 Tensile Test Result Graph

S.NO	COMPOSITE	FLEXURAL TEST			
		LOAD(N)	ELONGATION(mm)	FLEXURAL STRENGTH(MPA)	% OF ELONGATION
1	KEVLAR	500	32	131.25	19.51
2	E GLASS	730	29.5	191.625	17.98
3	CARBON FIBER	980	42.8	257.25	26.09
4	KEVLAR/E GLASS	540	38	141.75	23.17
5	KEVLAR/CARBON	1370	46.5	359.625	28.35
6	E GLASS/CARBON	1670	42.7	438.375	26.03
7	KEVLAR/E GLASS/CARBON	1250	46.4	328.125	28.29

Figure 15 Flexural Testing Results for 7 Composites

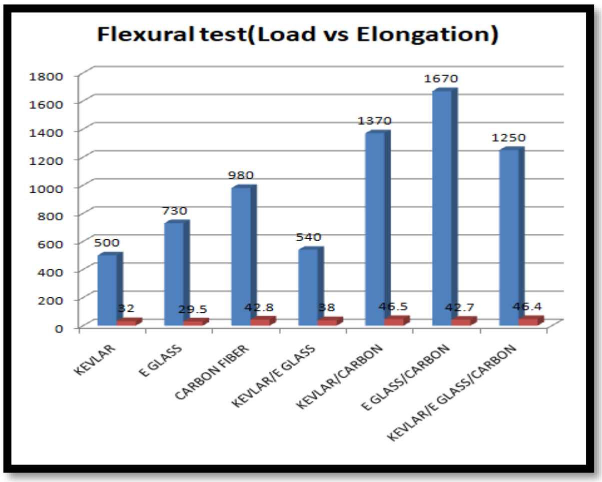

Figure 16 Graph 2 Flexural Test Result Graph

7. Impact Strength

S.NO	COMPOSITE	IMPACT TEST
		(J)
1	KEVLAR	5.7
2	E GLASS	6
3	CARBON FIBER	7.2
4	KEVLAR/E GLASS	8
5	KEVLAR/CARBON	8.2
6	E GLASS/CARBON	7.2
7	KEVLAR/E GLASS/CARBON	8.1

Figure 17 Flexural Testing Results for 7 Composites

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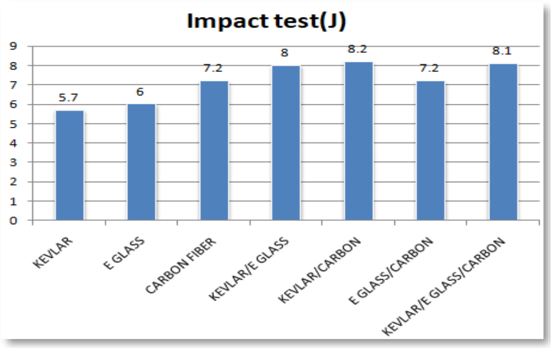

Figure 18 Graph 3 Impact Strength Result Graph

And finally concluded the Kevlar and Carbon fiber with 5grams of graphite powder hybrid material possess high impact strength compared to remaining compositions. (Figure 19)

7.1.Hardness Number

S.NO	COMPOSITE	HARDNESS NUMBER
1	KEVLAR	61.27
2	E GLASS	49.86
3	CARBON FIBER	65.01
4	KEVLAR/E GLASS	59.51
5	KEVLAR/CARBON	79.68
6	E GLASS/CARBON	64.6
7	KEVLAR/E GLASS/CARBON	58.2

Figure 19 After Testing of Hardness Test on All Materials

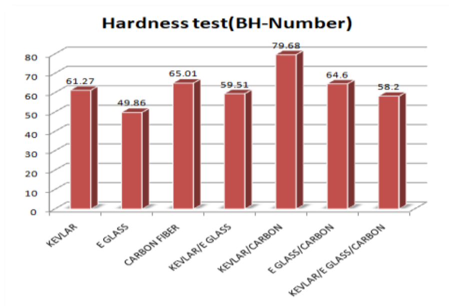

Figure 20 Graph 4 Hardness Number Result Graph

7.2.Dimensions of Alloy Wheel

- **Wheel:** The wheel is typically composed of two main parts—the rim and the disc.
- **Rim:** The rim is the outer part of the wheel where the tire is mounted.
- **Disc:** This is the central part of the rim that connects to the axle hub.
- **Offset:** The offset refers to the distance between the wheel's mounting surface (where it bolts to the hub) and the centerline of the rim. [5-8]
- **Flange:** The flange is the edge of the rim that holds both beads of the tire in place.
- **Bead Seat:** This is the area of the rim that contacts the tire bead, securing the tire in the radial direction.
- **Hump:** A raised section on the bead seat, the hump prevents the tire from slipping off the rim while the vehicle is in motion.
- **Well:** The well is the recessed area of the rim that allows for easier mounting and removal of the tire [9-10]

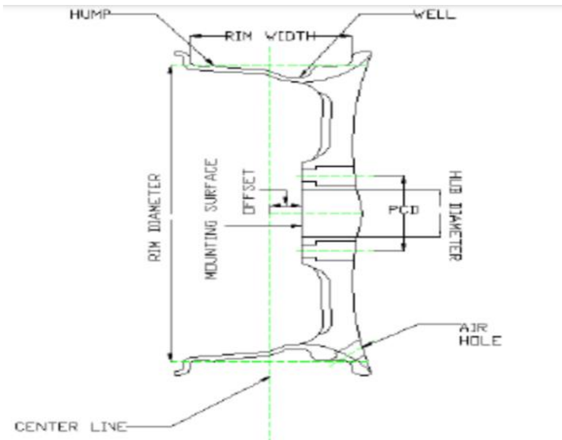

Figure 21 30 Sectional Image of the Disk

S.No	Parameters	Value
1	Rim diameter	350mm
2	Bolt circle diameter	87mm
3	Hole circle diameter	240mm
4	Width of rim	122mm

Figure 22 Dimensions of Alloy Wheel Rim

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7.3.Design Procedure in Catia

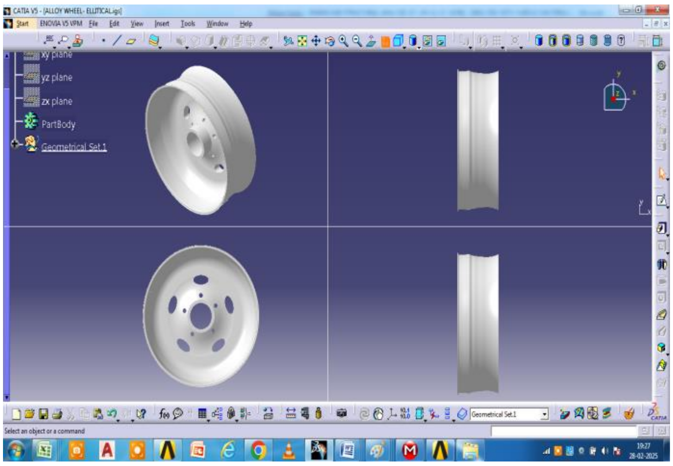

Figure 23 Multi View of Elliptical Spokes Shape of Alloy Wheel RIM

7.4.Mesh and Boundary Conditions

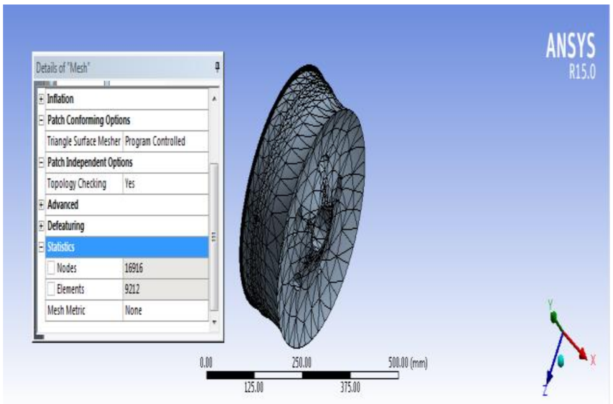

Figure 24 MESH with 16916 Nodes, 9212 Elemants

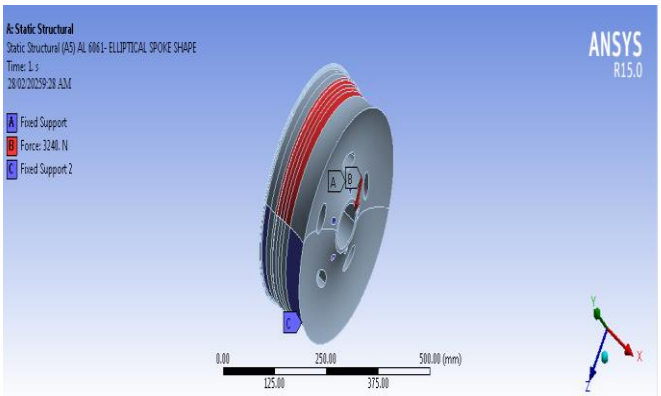

Figure 25 Fixed Supports and Applying Force 3240 N

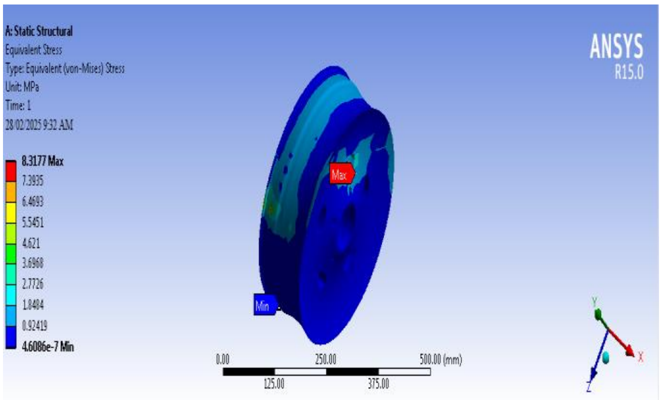

Figure 26 Equivalent Von-Misses Stress

7.5.Von-Misses Stresses Graph

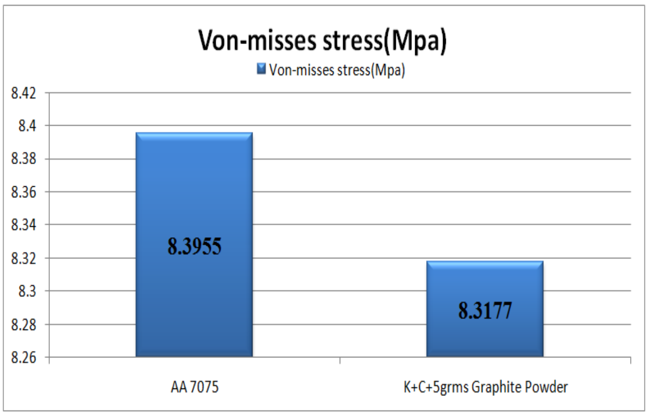

Figure 27 Von-Misses Stresses Graph

8. Conclusions & Future Scope

8.1.Conclusion

The objective of the present study is to investigate the mechanical properties of composite materials reinforced with various combinations of Kevlar, carbon fiber, and E-glass—specifically: Kevlar, carbon fiber, E-glass, Kevlar/carbon fiber, Kevlar/carbon fiber/E-glass, Kevlar/E-glass, and carbon fiber/E-glass. In all combinations, 5 grams of graphite powder were added, and epoxy resin was used as the matrix material. The composites were fabricated using the hand lay-up method. Mechanical properties such as tensile strength, flexural strength, impact resistance, and hardness were evaluated for each composite. The primary aim was to identify the most effective composite formulation among the seven combinations tested. Based on the results, the Kevlar/carbon fiber composite with 5 grams of graphite powder demonstrated superior performance across all tested parameters—tensile strength, impact resistance, flexural strength, and hardness. Therefore, this combination is recommended for applications requiring enhanced mechanical properties compared to the other tested composites.

8.2.Future Scope

- The extension of this thesis work can be done by considering the following points:
- The fiber can also take in the form of powder to fabricate the specimen which may increases the strength.
- Different type reins can be used to find the mechanical properties like strength, wear resistance
- By considering different process parameter and different composites which improves the properties of composites.

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