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# Effect of Reinforcements on Tensile Properties of Polymer Composites

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***Abstract:*** ***FRP allows the alignment of the glass fibres of thermoplastics to suit specific design programs. Specifying the orientation of reinforcing fibres can increase the strength and resistance to deformation of the polymer. Glass reinforced polymers are strongest and most resistive to deforming forces when the polymers fibres are parallel to the force being exerted, and are weakest when the fibres are perpendicular. E-Glass or electrical grade glass was originally developed for stand off insulators for electrical wiring. It was later found to have excellent fibre forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fibre glass. The original plastic material without fibre reinforcement is known as the matrix or binding agent. The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibres. The extent that strength and elasticity are enhanced in a fibre-reinforced plastic depends on the mechanical properties of the fibre and matrix, their volume relative to one another, and the fibre length and orientation within the matrix***

***Keywords: Thermoplastics, polymer matrix, composites, elasticity, binding agent***

## I. INTRODUCTION

Fibre-reinforced plastic (FRP) (also called fiber-reinforced polymer, or fiber-reinforced plastic) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass (in fibreglass), carbon (in carbon-fiber-reinforced polymer), aramid, or grapheme. Rarely, other fibres such as paper, wood, or asbestos have been used. The polymer is usually an epoxy, vinylester, aphene or polyester thermosetting plastic, though phenol formaldehyde resins are still in use.FRPs are commonly used in the aerospace, automotive, marine, and construction industries. Polymer is generally manufactured by step-growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers, the result is referred to as a plastic. Composite plastics refers to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties. Fibre-reinforced plastics are a category of composite plastics that specifically use fibre materials to mechanically enhance the strength and elasticity of plastics.

## II. MATERIALS AND PROCEDURE

### *A. Polymer Matrix Composite (PMC)*

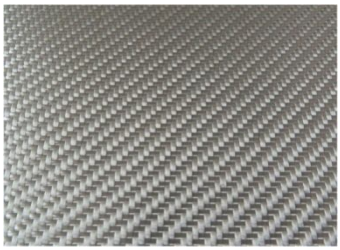
It is the material consisting of a polymer (resin) matrix combined with a fibrous reinforcing dispersed phase. Polymer Matrix Composites are very popular due to their low cost and simple fabrication methods.

Use of non-reinforced polymers as structure materials is limited by low level of their mechanical properties: tensile strength of one of the strongest polymers - epoxy resin is 20000 psi . In addition to relatively low strength, polymer materials possess low impact resistance.

*1)* Properties of polymer matrix composites
*a)* Very good strength
*b)* Excellent stiffness
*c)* Very high Fracture Toughness
*d)* Good abrasion resistance
*e)* Good puncture resistance
*f)* Good corrosion resistance
*g)* Moderate price.

*B. Introduction to Glass Fibre*

The use of advanced composite materials such as GFRP fiberglass rebar can help resolve typical deterioration problems that are associated with conventional steel reinforcement materials. The key advantage of advanced composites, when compared with traditional materials, is their ability to increase the service life of a concrete structure and provide a solid resistance against severe environmental conditions such as corrosive agents, aging, and degradation.Since FRP composites offer high strength-to-weight ratio and can be customized according to the project requirements, they enable structural engineers to complete a project with great ease. Following are some of the advantages and properties of FRP composites and why they are better than traditional materials:


E- Glass Fibre


S- Glass Fibre


C- Glass Fibre

1) *Introduction of E-Glass Fibre:* E-Glass or electrical grade glass was originally developed for stand off insulators for electrical wiring. It was later found to have excellent fibre forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fibreglass.

2) *Properties of E-Glass fibre*

*a) Design Properties*

*i)* High capacity of live loads
*ii)* Dimensional stability
*iii)* Flexible design to help meet structural needs
*iv)* Low thermal expansion coefficient
*v)* Aesthetics possibilities
*vi)* Non-magnetic and customizable
*vii)* Higher resistance against pyrolysis
*viii)* Better burn through resistance

*b) Mechanical Properties*

*i)* High tensile strength
*ii)* Better seismic resistance
*iii)* Resistance against atmospheric degradation and weathering
*iv)* Excellent resistance against freeze-thaw cycles
*v)* Good stiffness to weight ratio
*vi)* Resistant to deicing salts

*c) Cost*

*i)* Zero or less maintenance cost
*ii)* Savings due to rapid project completion
*iii)* Lower user cost
*iv)* Considerable decline in price

*C. Introduction Of Graphene*

Graphene is a one-atom-thick layer of carbon atoms arranged in a hexagonal lattice. It is the building-block of Graphite (which is used, among other things, in pencil tips), but graphene is a remarkable substance on its own - with a multitude of astonishing properties which repeatedly earn it the title “wonder material”. Graphene is the thinnest material known to man at one atom thick, and also incredibly strong - about 200 times stronger than steel. On top of that, graphene is an excellent conductor of heat and electricity and has interesting light absorption abilities. It is truly a material that could change the world, with unlimited potential for integration in almost any industry. Graphene is an extremely diverse material, and can be combined with other elements (including gases and

metals) to produce different materials with various superior properties. Researchers all over the world continue to constantly investigate and patent graphene to learn its various properties and possible applications.

1) *Properties of Graphene:* Due to the strength of its 0.142 Nm-long carbon bonds, graphene is the strongest material ever discovered, with an ultimate tensile strength of 130,000,000,000 Pascals (or 130 gigapascals), compared to 400,000,000 for A36 structural steel, or 375,700,000 for Aramid (Kevlar). Not only is graphene extraordinarily strong, it is also very light at 0.77milligrams per square metre (for comparison purposes, 1 square metre of paper is roughly 1000 times heavier). It is often said that a single sheet of graphene (being only 1 atom thick), sufficient in size enough to cover a whole football field, would weigh under 1 single gram.

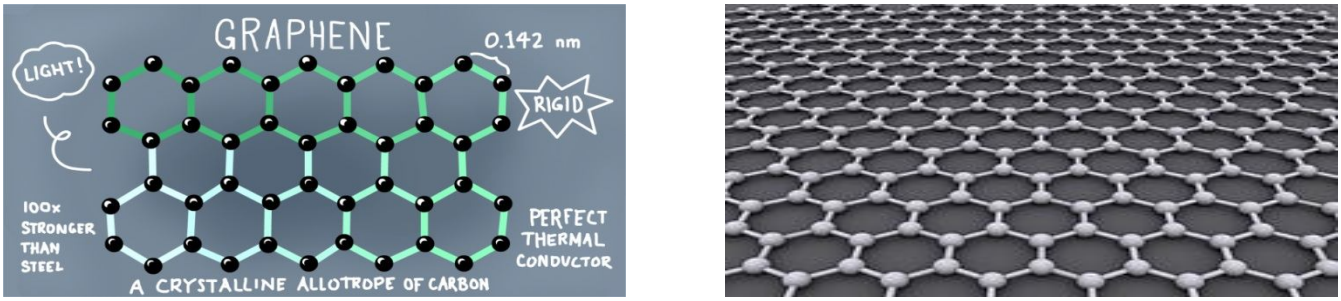



Figure 1 Graphene is an atomic-scale hexagonal lattice made of carbon atoms

2) *Advantage of Graphene*

*i)* It is two hundred times stronger compare to steel and incredibly flexible.

*ii)* It is thinnest material possible and it is completely transparent which can transmit more than 90 % of the light.

*iii)* It can transfer electrons at much faster rate compare to silicon. It can pass at the speed of 1000 Kms/sec which is about 30 times fast compare to silicon.

*iv)* It can be used in flexible electronic newspaper, foldable televisions etc.

*v)* It can be used in clothing which uses graphene based photo-voltaic cells as well as super conductors. Due to this tablets and mobile phones can be charged in minutes while in the pockets itself.

*vi)* It can be used for wide variety of applications such as flexible displays (OLEDs, LCDs), RAM, energy efficient transistors, energy storage devices, textile electrodes, copper nano wires, thermal management, spintronics etc.

*D. Introduction to Epoxy Resin*

Epoxy resins are much more expensive than polyester resins because of the high cost of the precursor chemicals most notably epi chloro hydrin. However, the increased complexity of the 'epoxy' polymer chain and the potential for a greater degree of control of the cross linking process gives a much improved matrix in terms of strength and ductility. Most epoxies require the resin and hardener to be mixed in equal proportions and for full strength require heating to complete the curing process. This can be advantageous as the resin can be applied directly to the fibres and curing need only take place at the time of manufacture. And known as pre-preg or pre impregnated fibre.

1) *Properties of Epoxy*

*i)* High shear and peel strength

*ii)* Tough and resilient

*iii)* Good resistance to dynamic loading

*iv)* Bonds a wide variety of materials in common use

*v)* Epoxy also has excellent resistance to chemical.

2) *Advantages of Epoxy Resin*

*1)* Low shrink during cure

*2)* Excellent moisture resistance

*3)* Excellent chemical resistance

*4)* Good electrical properties

*5)* Increased mechanical and fatigue strength

*6)* Impact resistant.

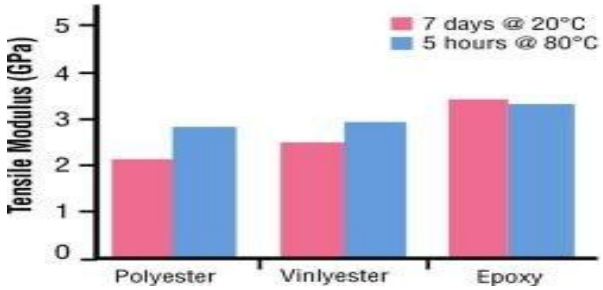



Figure 2. Comparison of polyester, vinylated, epoxy Tensile Modulus

*E. Compression Molding*

Compression molding is a popular manufacturing technique for composite parts. In particular, the development of high-strength sheet molding compounds drove wide adoption of compression molding process in automotive and appliance applications. In this chapter, we present some advantages and disadvantages of compression molding. We also introduce molding materials for compression molding such as sheet molding compound and bulk molding compound. To obtain high quality products, it is important to optimize mold design and processing conditions. Process modeling, such as flow and cure analysis, is especially useful to predict the knit line formation, part curing, fiber orientation and separation in the final product.


Figure 3. Compression Molding machine

*1) Advantages of the Compression Molding Process*

*a)* Good surface finish with different texture and styling can be achieved.
*b)* High part uniformity is achieved with compression molding process.
*c)* Good flexibility in part design is possible.
*d)* Maintenance cost is low.

*F. Fabrication Of Composite Material*

*1) Compositions of Composite Material:* Compositions of composite material for preparation of sample for Testing are shown in table 2.2

| Specimen No.: | Epoxy Resin :Hardner Ratio | Graphene Weight (%) | E-Glass Fibre (No. of layers) |
|---|---|---|---|
| 1 | 10:6 | 9 % | 3 layers |
| 2 | 10:6 | 12 % | 3 layers |

Table 1 Compositions of composite material

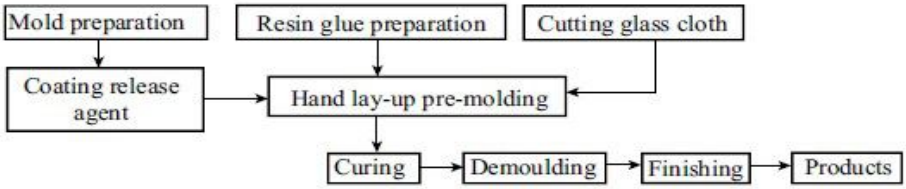
The fabrication of the polymer matrix composite was done at room temperature. The required ingredients of resin and hardener were mixed thoroughly in beaker.

2) *Dough Preparation:* The required mixture of resin & hardener were made by mixing them in (10:6) and (10:5) parts in a beaker by stirring the mixture in a beaker by a rod taking into care that no air should be entrapped inside the solution. graphene were mixing with dough ratio is 9 % and 12% of the epoxy composition.

Figure 4. Dough and Mould preparation

3) *Mould Preparation:* Two mild steel moulds of size 300 X 300 X 10 (mm) were used for casting of polymer matrix composite slabs. The moulds made of mild steel. The mould comprises of two plates one top & other bottom &third square mould cavity inside.

4) *Castings of Samples:* The dough prepared is transferred to mould cavity by care that the mould cavity should be thoroughly filled. Leveling was done to uniformly fill the cavity.It is done by hand layup technique as shown below




5) *Curing:* Curing was done at room temperature for approx. 24 hrs in Compression mouding machine. After curing the mould was opened slab taken out of the mould and cleaned.

Figure5. Curing in Compression MoldingMachine

*G. Tensile Test*

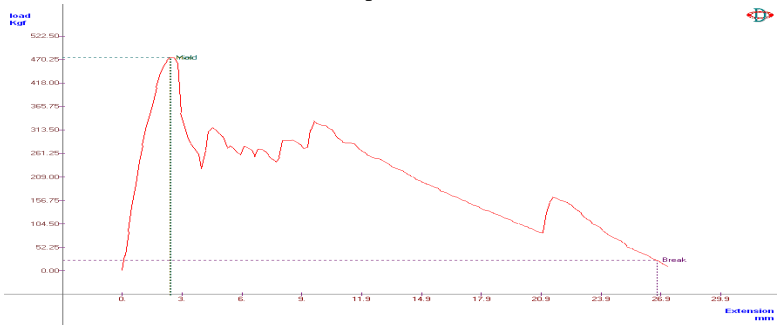
The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. The force per unit area (MPa or psi) required to break a material in such a manner is the ultimate tensile strength or tensile strength at break. Tensile properties indicate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, tensile strength, yield point, yield strength and other tensile properties.


Figure 6. Tensile Testing Machine

*1) Tensile & Elongation Test Report For Specimen - 1*

| Specimen | 1 (9 % Graphene) | | |
|---|---|---|---|
| Ref. Standard | ASTM D 3039 | | |
| Grip Length | 165 mm | Guage Length | 125 mm |
| Sample Width | 25 mm | Sample Thickness | 3 mm |

Graph View



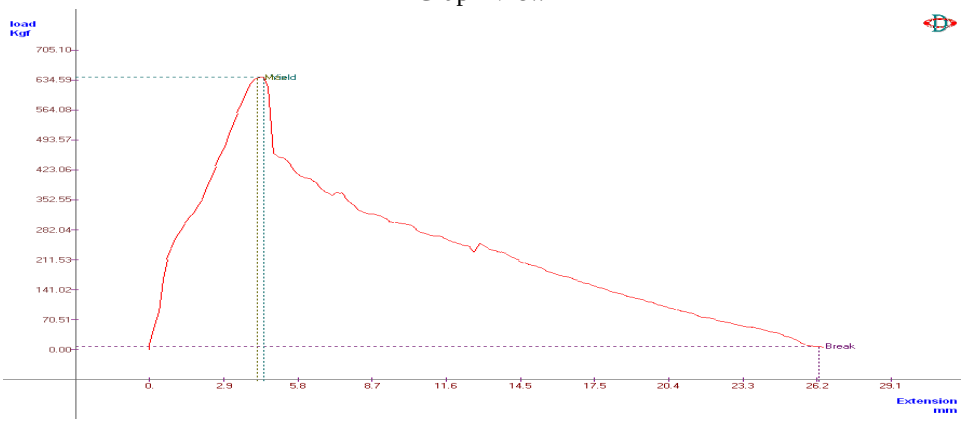

Results Obtained

| Sr. No. | Results | Value | unit |
|---|---|---|---|
| 1 | Area | 0.75 | $cm^2$ |
| 2 | Yield Force | 475.00 | Kg |
| 3 | Yield Elongation | 2.43 | mm |
| 4 | Break Force | 24.0 | Kg |
| 5 | Break Elongation | 26.67 | mm |
| 6 | Tensile Strength at Yield | 633.33 | $Kg/cm^2$ |
| 7 | Tensile Strength at Break | 32.00 | $Kg/cm^2$ |
| 8 | % Elongation | 16.16 | % |

*2) Tensile & Elongation Test Report For Specimen - 2*

| | | | |
|---|---|---|---|
| Specimen code | 2 (9 % Graphene) | | |
| Ref. Standard | ASTM D 3039 | | |
| Grip Length | 165 mm | Guage Length | 125 mm |
| Sample Width | 25 mm | Sample Thickness | 3 mm |

Graph View




Results Obtained

| Sr. No. | Results | Value | unit |
|---|---|---|---|
| 1 | Area | 0.75 | $cm^2$ |
| 2 | Yield Force | 641.00 | Kg |
| 3 | Yield Elongation | 4.49 | mm |
| 4 | Break Force | 8.0 | Kg |
| 5 | Break Elongation | 26.24 | mm |
| 6 | Tensile Strength at Yield | 854.67 | $Kg/cm^2$ |
| 7 | Tensile Strength at Break | 10.67 | $Kg/cm^2$ |
| 8 | % Elongation | 15.90 | % |

## III. CONCLUSION

*A.* The Mechanical properties of the composites are Improving, when graphene is add with matrix as epoxy resin during the prepare the composite.

*B.* Tensile strength of 9 % Graphene Specimen is 633.33 $kg/cm^2$ and 12 % Graphene Specimen is 854.67 $kg/cm^2$ . Here Tensile Strength of the 12 % of Graphene Specimen are improved by adding of 3% Extra graphene to the Composite.

*C.* Tensile strength of composites are gradually increasing, when increase weight % of graphene is add with matrix as Epoxy Resin During prepare the Composite.

*D.* Mechanical properties are developed by adding the graphene to the composite.

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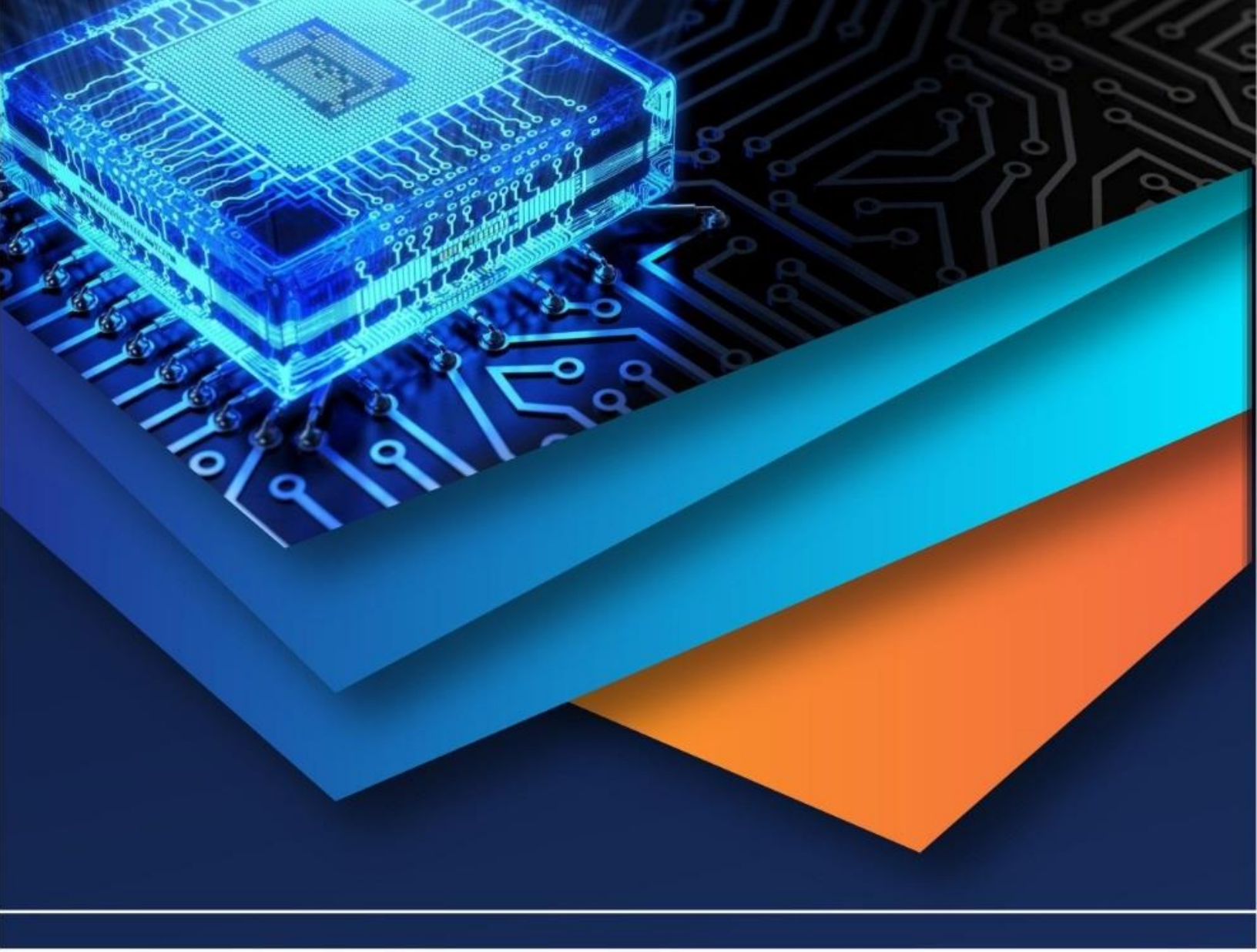

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