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Mechanical Characterization and Feasibility Analysis of Polymer Fiber Composite Material

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Abstract: The most prevalent reinforcing component in composite materials is carbon fiber. However, obtaining the monofilament's performance metrics of carbon fiber is a challenging task. In this study, we have used PolyVinyl Chloride (PVC) sheets having low mechanical properties. Our goal is to improve the mechanical properties of PVC sheets with the wrapping of carbon fiber. The wrapping of carbon fiber is done by the Hand Lay up method. In this paper, we analyze and compare the mechanical properties of the sheet by using two, four and six layers of carbon fiber on PVC sheets . The main aim of this study is to enhance the mechanical properties of PVC sheets by increasing the number of layers of carbon fiber without replacing the sheet and without enhancing the overall cost.
Keywords: Mechanical properties, PVC, Carbon fiber, Hand Lay up.

I.INTRODUCTION

Composite Materials can be applied to a wide range of different loading conditions. The majority of Mechanical constraints and environmental factors are critical.To enhance the effectiveness of composites materials, their behaviour under various conditions has been studied [1]. The primary environmental threats are temperature, moisture, radiation, and/or contact with a wide range of chemicals' These components can have an impact on composites' thermal and mechanical properties in various ways.When composites are heated to temperatures close to the glass transition temperature, thermomechanical effects caused by Polymer softening and/or decomposition may occur [2]. A growing number of companies, including those that manufacture wind turbines, storage tanks, sports equipment, and land, air, and sea vehicles, are using carbon fibre reinforced polymer matrix composite (CFRP) materials shown in Fig. 1. Due to their high specific strength, high specific stiffness, low density, ease of integration for part assembly, flexibility, and design freedom, CFRPs are in high demand.By 2025, it is predicted that there would be 20 kt of CFRP trash generated annually. The global demand for carbon fibre is predicted to reach 117 kilo tonnes (kt) and 194 kt, respectively, in 2022 [3]. The fast expansion of the use of CFRPs in both established and developing industrial sectors creates significant environmental concerns in terms of wastes such off-cuts produced during composite manufacture (up to 40%) and end-of-life CFRP products. The characteristics of the polymer matrix are frequently what govern how CFRP is recycled. Around 80% of polymer matrix composites (PMCs) are currently made of thermoset polymers (such as epoxy and unsaturated polyester), which are preferred because of their high mechanical strength, high chemical and heat resistance, dimensional stability, and durability [4].

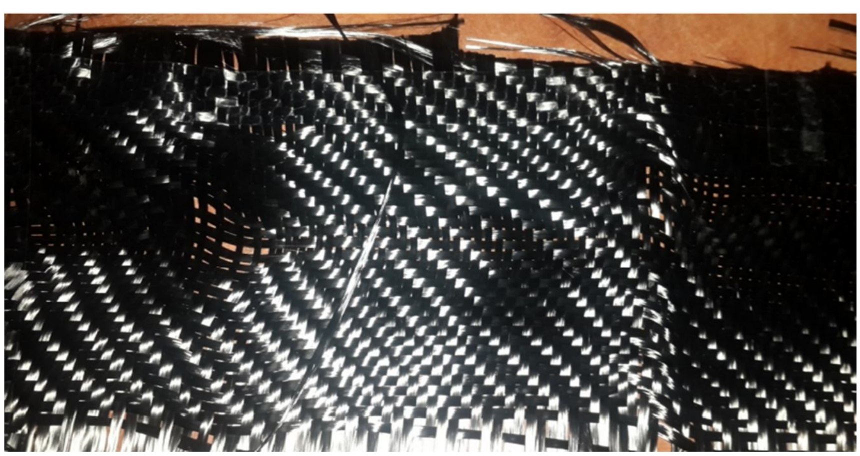

Fig. 1. Carbon Fiber

II.RELATED WORK

[5]proposed carbon fibers recycled from carbon fiber/epoxy resin composites using supercritical n-propanol. Supercritical n-propanol process was used in a semi-continuous flow reactor to recycle carbon fiber from scrap epoxy resin/carbon fiber composites. The properties of the recycled carbon fibre are characterized in this paper using single tensile test, 0SEM, XPS and micro-droplet test for interfacial bonding strength. Mechanical properties are maintained. However, the surface oxygen decreases significantly mainly due to the decrease of the surface C–OH group. [6] proposed Mechanical properties and failure behaviour of composites under the influence of moisture .The properties of the epoxy-based composites were influenced by the absorbed moisture only in specimens in which fibres were orientated perpendicular to the load direction. Examinations of the fracture surfaces of the carbon fibre/epoxy composites showed that the moisture led to an increase in interface failure. The epoxy matrix becomes softer with moisture absorption, 18 and the fibre-matrix adhesion poorer carbon fiber-reinforced polymer composites under the influence of moisture. [7] proposed Rapid evaluation of long-term thermal degradation of carbon fibre epoxy composites The initial goal was to determine the effects of thermal degradation on two commonly used composites. Mass loss, loss were interpreted by the initial chemical composition and the degradation of the matrix [8]proposed Hybrid composite laminates reinforced with glass/carbon woven fabrics for lightweight load bearing structures . To effectively improve the tensile, compressive and flexural strength of the plain glass fibre composite, glass/carbon (50:50) fibre reinforcement was used either by placing the carbon layers at the exterior or by placing different fibre types alternatively. With the same hybrid composition, the stacking sequence did not show noticeable influence on the tensile properties but affected the flexural and compressive properties significantly [9]proposed carbon fibre epoxy-matrix composite as a sensor of its own strain . Unidirectional continuous carbon fibre reinforced epoxy was found to be able to sense its own strain in the fibre direction, due to its longitudinal electrical resistance decreasing reversibly and its transverse resistance increasing reversibly upon longitudinal tension [10] proposed Fatigue behaviour of oil palm fruit bunch fibre/epoxy and carbon fibre/epoxy composites. Unidirectional tensile tests were carried out on oil palm fruit bunch fibre (OPFBF)/epoxy composite and carbon fibre (CF)/epoxy composite to determine their modulus and ultimate tensile stress (UTS). The UTS determined from these tests were then used as the fatigue test parameters. Two different values of fibre volume ratios, Vf, namely 35 studied for OPFBF/epoxy composite The OPFBF composite Vf = 55 which failed in fatigue test has the same fracture surface as observed in tensile test. [11] proposed idea of Damping properties of thermoplastic-elastomer interleaved carbon fiber-reinforced epoxy composites. Interleaving of fiber-reinforced composites had a significant effect on the damping properties. In this study, several types of thermoplastic-elastomer films were used as interleaf materials. Laminate stacking sequence (layup arrangements of carbon-fiber prepreg, lay-up number and so on) determined the resonant frequencies of the laminates damping effects depended not only on the visco elastic properties of the interleaved polymer material but also on the arrangements of the reinforcing carbon fiber in the laminates which controlled the stiffness of the intralaminar zone and the strain of the interleaf films.

III.MATERIALS

A. Polyvinyl Chloride (PVC)

Polyvinyl chloride (PVC) is a material with enormous technical and environmental significance. PVC has the world's second largest production capacity among thermoplastics, with a demand exceeding 35 million tonnes per year. PVC is a common thermoplastic resin that has been used in a variety of fields due to its flexible molecular chain and excellent overall performance. A manufactured fibre in which the fiber-forming substance is any long chain synthetic polymer containing at least 85% by weight vinyl chloride units (FTC definition) [12]. PVC fibres are also referred to as vinyon fibres or chloro-fibers. Elastomeric fabrics are made from pure PVC fibres. Outdoor fabrics, such as tarps, awnings, rain gear, and fishing nets, also use them. Chlorinated hydrocarbons and aromatic solvents are soluble. Water, alcohols, concentrated acids, and alkalis are all insoluble. When removed from the flame source, it extinguishes with a green smoky flame and emits HCl. Cross section = erratic. 10% PVC properties: Tensile strength = 2.7-3.0 g/denier (dry or wet) 12-20% elongation (dry or wet) 0% moisture regain PVC fill is used as shrink and stretch wrap in the industrial sector.

B. Sand Paper

Sandpaper grit size is typically expressed as a number that is inversely proportional to particle size. A small number, such as 20 or 40, represents coarse grit, while a large number, such as 1500, represents fine grit. Sandpaper comes in a variety of grit sizes and is used to remove material from surfaces, either to make them smoother (as in painting and wood finishing), to remove a layer of material (such as old paint), or to make the surface rougher (as in glueing). When describing the paper, it is common to use the name of the abrasive, such as "aluminium oxide paper" or "silicon carbide paper" [13].

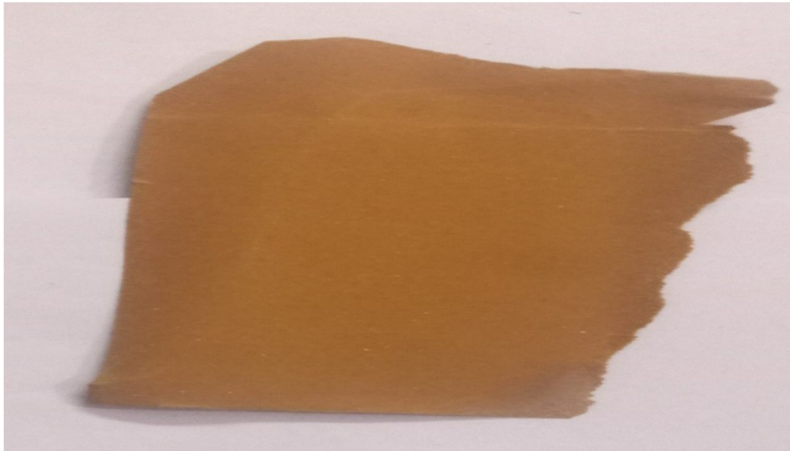

Fig. 2. Sand paper

C. Epoxy

Epoxy is the most commonly used polymer matrix for carbon fibres. The material is divided into two categories in high performance continuous fiber composites epoxy, which are used in different environments depending on temperature and moisture variations [14]. There are two types: those cured at a lower temperature (120°C) and used in components exposed to low or moderate temperature variations, such as sports equipment, and those cured at a higher temperature (175°C). The latter are used in high-performance components that are subjected to high temperature and moisture variations, such as those found in aircraft structures. The curing process includes the addition of a hardener and possibly an accelerator, as well as a temperature cycle ranging from 60 to 180°C. It is the sum of mechanical properties.

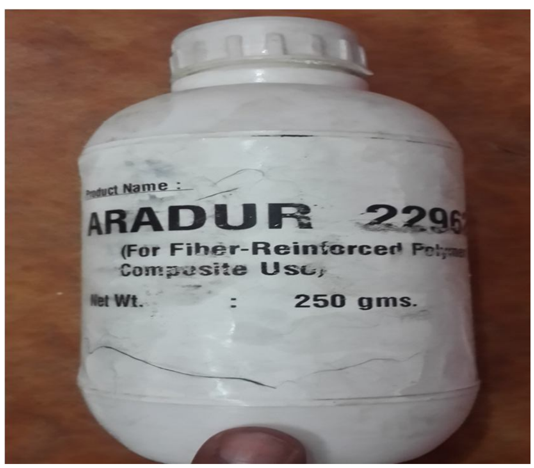

Fig. 3. Hardener

IV.PROPOSED APPROACH

A. Specimen Preparation

As indicated in Fig.4. First and basic steps is preparation of a specimen for a tensometer. For this I used a power hacksaw blade and cut it in the standard size. Second step which I followed is with the help of sandpaper roughness induced because of robbing the whole part it is required to increase roughness of surface so that proper bonding should take place between fiber and plastic. Mixing of epoxy and hardener is done by volume ratio which means for every 100 ml of epoxy there is 25 ml of hardener. Proper care should be taken in mixing because if the required ratio is not met then there is no proper combination that takes place between epoxy and hardener. After mixing epoxy and hardener in a proper ratio, the next step is to apply the mixer thoroughly to the surface of plastic fiber with the help of a hand brush. After solidification of the carbon layer we get a solid and hard specimen which is cut by a grinder to get proper shapes of specimen for tensile test, impact and hardness test.

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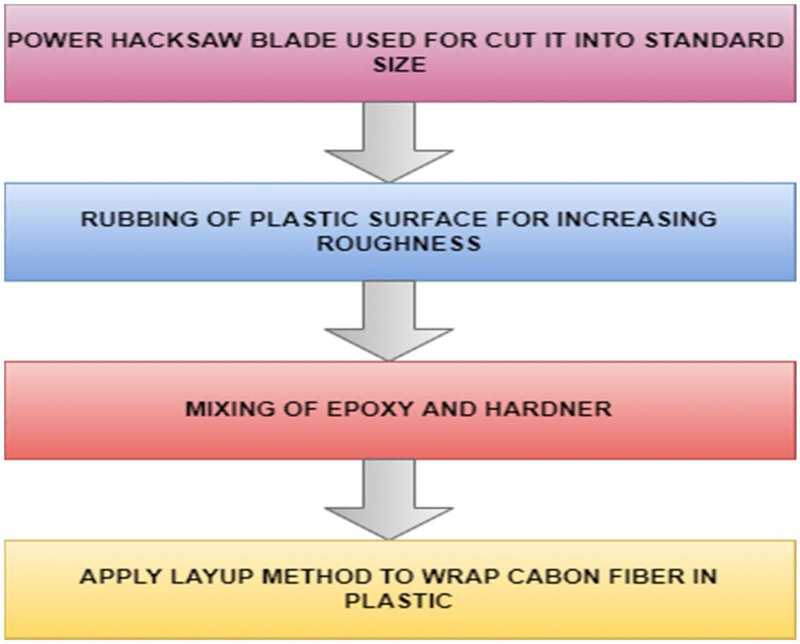

Fig. 4. Steps to prepare specimen

B. *Hand Lay Up Technique*

The simplest way for processing composites is hand lay-up. To prevent polymer from adhering to the mould surface, a release gel is first sprayed over it. To achieve a high-quality surface finish for the product, thin plastic sheets are employed at the top and bottom of the mould plate. Hand lay-up technique was used to create the composite laminates. To make removing composite laminates from the releasing sheet simple, silicon spray was applied [15]. A consistent spreader of epoxy polymer was used to cover the releasing sheet. brush. Epoxy to hardener ratio in the matrix was 10:1. Then apply a single layer of carbon fiber on it and again apply a layer of mixer on the surface of the carbon layer. Here by increasing layer by layer of carbon fiber we get different specimens of carbon fiber. After applying a layer of mixer proper temperature is maintained at 22 degree for five to six hours for drying the surface of the layer.

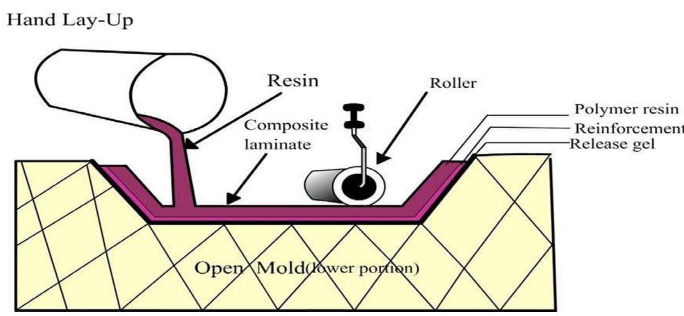

Fig. 5. Hand Lay Up Method

V.RESULTS & DISCUSSIONS

In this study, hardness tests were performed with the help of Rockwell Hardness Tester by injecting the specimen prepared by us as shown in fig. 6 and 7.

Fig. 6. Specimen wrapping without carbon fibre

Fig. 7. Specimen wrapping with carbon fibre

A. Hardness Test

The Rockwell tests constitute the most common method used to measure hardness because they are so simple to perform and require no special skills. Several different scales may be utilized from possible combinations of various indenters and different loads, which permit the testing of virtually all metal alloys (as well as some polymers). 46 Indenters include spherical and hardened steel balls having diameters (1.588,3.175, 6.350 and 12.70 mm), and a conical diamond (Brale) indenter, which is used for the hardest materials. The increase in hardness values of plastic fiber after wrapping carbon fiber as shown in fig. 9 and without wrapping of carbon fiber is shown in fig. 8 but overall hardness mainly depends upon the hardener which we used.

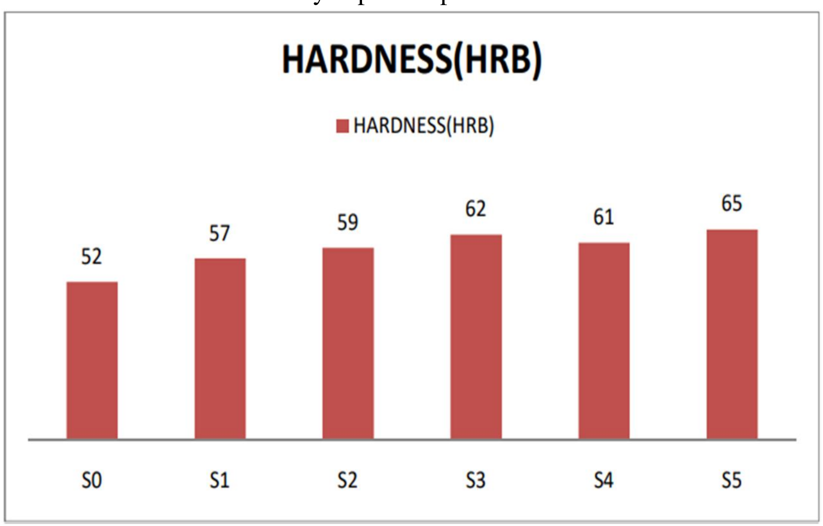

Fig. 8. Hardness test without carbon fibre

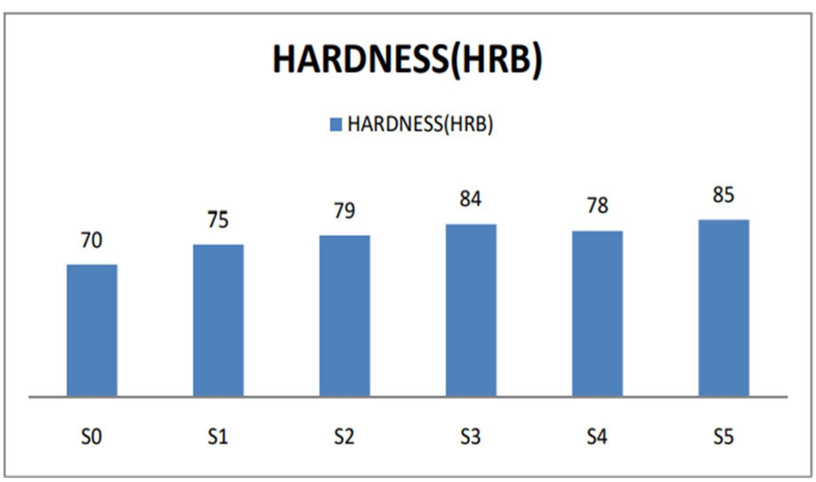

Fig. 9. Hardness test with carbon fibre

VI.CONCLUSION & FUTURE SCOPE

The results confirmed that after wrapping carbon fiber in simple low strength plastic there is increase in all mechanical properties mainly tensile strength ,hardness and toughness which increases the durability and life span of component of either any machines or automobile part for example bonnet ,bumper etc.In future, Heat treatment can be done to improve properties. The experiment can be extended by increasing layer of carbon fiber, the experiment can be further extended by using better techniques like Vacuum Assisted Resin Transfer Molding (VARTM) or Vacuum Injection Molding (VIM), moisture absorption test and density variation test can also be find, mode of fracture can also be find.

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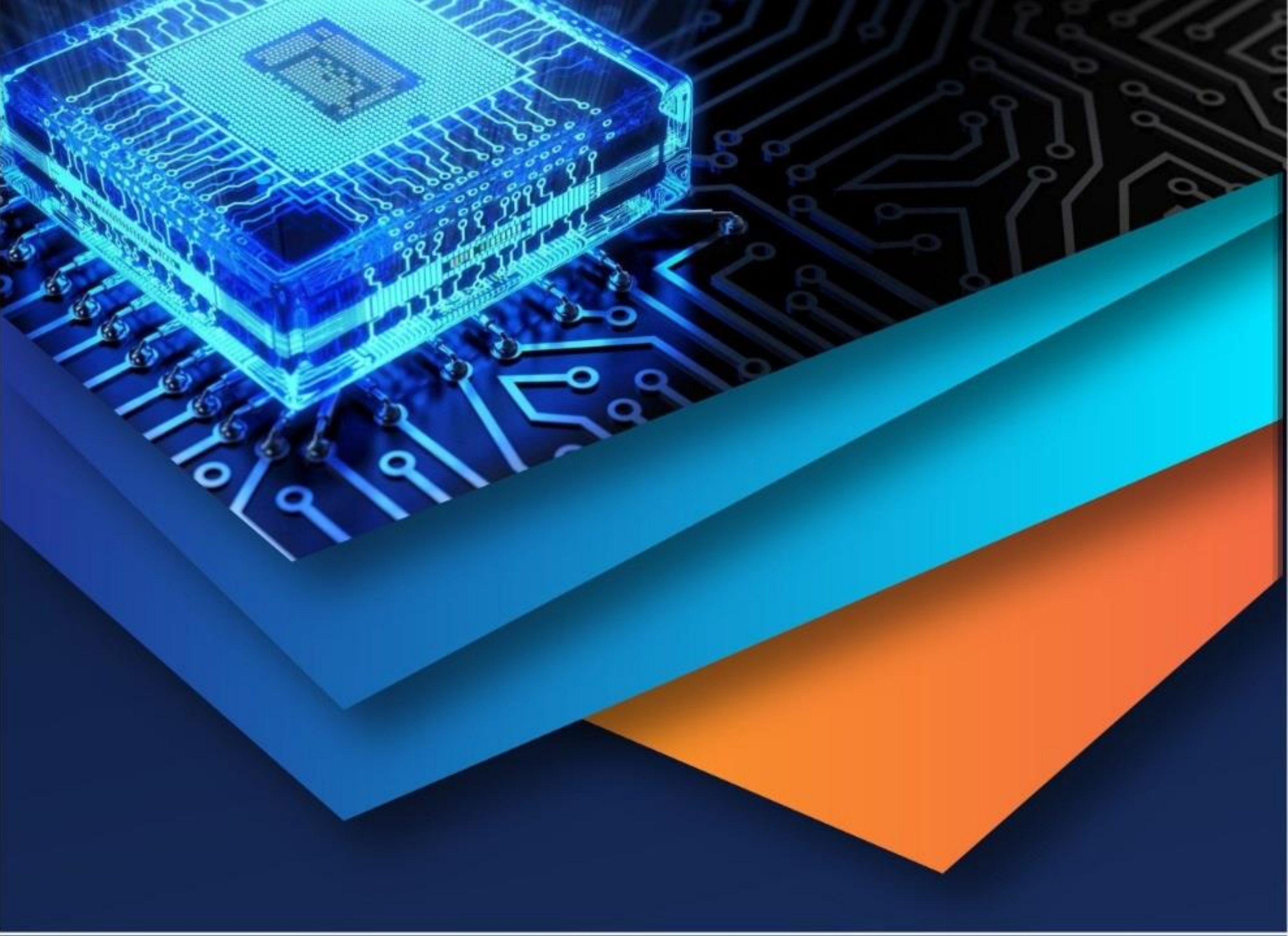

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