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Determination of Mechanical Properties of Hybrid Composite

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Abstract: Manufacturing of composite laminates is the peculiar member of science that encounter its immense utilization in various industrial areas such as sporting, automotive, aerospace and marine industries. The superior properties of composites such as stiffness, better mechanical properties, low density, and lightweight make it a candidate in engineering applications. The continuous research in this area is due to the need for seeking alternative materials with increased performance. In this report, the basalt fiber E-glass reinforced composite mechanical properties has investigated. The basalt fiber E-glass composite was formulated with hand layup moulding technique. Mechanical properties such as tensile, flexural strength and impact strength of the basalt fiber E-glass composite have been analysed.
Keywords: Basalt fiber ,E-glass fiber ,Composite Reinforcement ,Matrix Phase ,Mould.

I. INTRODUCTION

Fibres can be generally defined as thread-like structures that are thin, long, and flexible. The three main sources of fibres are plants,animals and minerals. Fibers are classified by their chemical origin, falling into two groups or families: natural fibers and manufactured fibers. Manufactured fibers are also referred to as manmade or synthetic fibers.

Fiber composites are engineered materials made of a composite matrix material, typically a polymer or resin, that is reinforced with fibers. These fibers can be made from natural materials such as wood or flax, or synthetic materials such as carbon or fiberglass. The addition of the fibers to the matrix material can improve the strength, stiffness, and other physical properties of the material. Fiber composites can be used in a variety of industrial and consumer applications, including aerospace, automotive, construction, and sports equipment [1].

Natural fibers are those that occur in fiber form in nature. Traditionally, natural fiber sources are broken down into animal, plant, or mineral. Fibers from plant or vegetable sources are more properly referred to as cellulose-based and can be further classified by plant source. Except for silk, all-natural cellulose- and protein-based fibers are obtained in short lengths and are called staple fibers. Silk is a continuous filament fiber.

A. *Overview Of Composites*

Over the last thirty years composite materials, plastics and comics have the dominant emerging materials. The volume and number of application of composite materials have groups steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications.While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective.

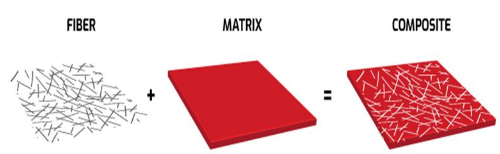

Fig-1 Fiber Composite

The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. It is obvious. especially for composites, that the improvement, in manufacturing technology alone enough to overcome the cost hurdle.

It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals. The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent is recent years.

The increased volume has resulted in an expected reduction in costs. High performance can now be found in such diverse applications as composite armoring designed to resist explosive impacts, fuel cylinders for natural gas vehicles, windmill blades, industrial drive shafts, support beams of highway bridges and even paper making rollers. For certain applications, the use of composites rather than metals has in fact resulted in savings of both cost and weight. Some examples are cascades for engines, curved fairing and fillets, replacements for welded metallic parts, cylinders, tubes, ducts blade containment bands etc. Further, the need of composite for lighter construction materials and more seismic resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases dead weight but also absorbs the shock & vibration through tailored microstructures.

Composites are now extensively being used for rehabilitation strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Unlike conventional materials (e.g., steel), the properties of the composite material can be designed considering the structural aspects. A composite material consists of two or more physically and/or chemically distinct, suitably arranged or distributed phases, with an interface separating them.

It has characteristics that are not depicted by any of the components in isolation. Most commonly, composite materials have a bulk phase, which is continuous, called the matrix, and one dispersed, non-continuous, phase called the reinforcement, which is usually harder and stronger. The function of individual components has been described.

1) E-glass Fiber

E-glass fiber, one of the most commonly used glass fibers in the fiberglass industry, is made from alumino-borosilicate glass with less than 1% w/w alkali oxides. The typical production of E-glass fiber involves the melting of raw materials at about 1370°C, followed by fiberization through fine bushings. This type of glass fiber is predominantly used due to its relatively low cost and favorable mechanical properties.

Fig-1.1 E glass fiber

Properties

Good Electrical Insulator: Excellent insulating properties make E-glass fiber ideal for electrical applications.

High Strength and Stiffness: Although not as strong or stiff as some advanced fibers, E-glass fibers provide a good strength-to-weight ratio.

Cost-Effective: E-glass fibers are less expensive compared to other specialty fibers, making them widely accessible for various applications.

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Uses

Uses for regular glass fiber include mats and fabrics for thermal insulation, electrical insulation, sound insulation, high-strength fabrics or heat- and corrosion-resistant fabrics. It is also used to reinforce various materials, such as tent poles, pole vault poles, arrows, bows and crossbows, translucent roofing panels, automobile bodies, hockey sticks, surfboards, boat hulls, and paper honeycomb. It has been used for medical purposes in casts. Glass fiber is extensively used for making FRP tanks and vessels.

Resin

In polymer chemistry and materials science, a resin is a solid or highly viscous substance of plant or synthetic origin that is typically convertible into polymers.

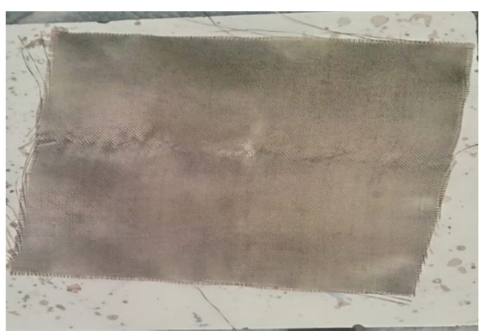
There are two main types of resin: thermoplastic and thermosetting resins.

II. MATERIALS AND PROCEDURE

A. Materials

- basalt fiber
- E-Glass fiber
- Unsaturated polyester resin
- Hardener.
- accelerator (Cobalt).

2.1 e glass fiber



2.2 basalt fiber

Density.

The theoretical density of composite material can be calculated using the formula given by

$$= ((w_2 - w_1))/((w_4 - w_1) - (w_3 - w_2))$$

W_1=weight of empty pycnometer.

W_2=pycnometer with basalt fiber.

W_3=pycnometer with water and fiber.

Density of basalt fiber

By using pycnometer, we are going to calculate density.

Density of basalt fiber

W_1=21.59g

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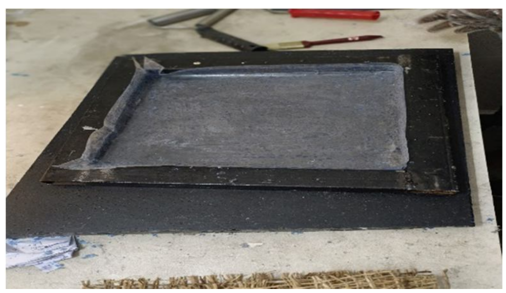
W_2=23.17g
W_3=47.57g
W_4=46.73g
= ((23.17-21.59))/((46.73-21.59)-(47.57-23.17))
=1.59/ 0.74
=2.135 g/cm^3.

Density of e-glass fiber
W_1=21.59g.
W_2=23.02g.
W_3=47.37g.
W_4=46.73g.
$=(23.02 - 21.59)/((46.73 - 21.59) - (47.37 - 23.02))$
=1.81g/cm^3.

Calculation of mould preparation.
Mas = volume ×density
$W_W = W_f + W_m$.
When the mould prepared by100% resin.
The volume of mould
30×30×0.3=270 cm^3.
Resin mass=volume ×density of resin
270×1.15=310.5g.



2.3Mould preparation

When mould prepared by 100% basalt fiber.
Mass of basalt = volume ×density of basalt
270×2.13=576.45
For the preparation of 100% e glass fiber.
Mass of e glass=270×1.81=488.7g

Sample-1:
4 layers of bi directional basalt fiber.
4 layers of bi directional e glass fiber.
Weight of basalt fiber =70g.
Weight of e glass fiber =129g.
Percentage of basalt fiber.

$$= (total\ layers\ weight\ of\ basalt)/(100\%\ mould\ weight\ of\ basalt) \times 100$$

$= 70/576.45 \times 100$=12.14%

Percentage of E-glass fiber

$$= (total\ layers\ weight\ of\ e\ glass\ fiber)/(100\ mould\ weight\ nof\ e\ glass\ fiber) \times 100$$

$= 129/488.7 \times 100 = 26.39\%$

Total fiber percentage
$W_f = W_b + W_e$

=12.14+26.39

W_f = 38.53%.

Percentage of resin

$W_c = W_f + W_m$

W_m=100-38.53

=61.47

Percentage of resin =61.47%

Weight of resin

= 310.5×61.47/100

=190.86 grams.

Sample-2

3 layers of basalt fiber.

3 layers of e-glass fiber.

Weight of basalt fiber = 49.3g.

Weight of e-glass fiber = 97.44g

Percentage of basalt fiber

$W_b = (Total\ layers\ of\ weight\ fiber) / (100\%\ mould\ weight) \times 100$

$W_b = 49.3 / 576.45 \times 100$

W_b=8.5%.

Percentage of e-glass fiber

$= (total\ layers\ weight\ of\ fiber\ ) / (100\%\ mould\ weight\ of\ fiber) \times 100$

$97.44 / 488.7 \times 100 = 19.93\%$

$W_f = W_b + W_e$

= 8.5+19.93

W_f = 28.48%.

Percentage of resin

$W_c = W_f + W_m$

$100 = 28.48 + W_m$

W_m=100-28.48

W_m=71.52%

Weight of resin

=310.5×71.52/100

=222.06 g.

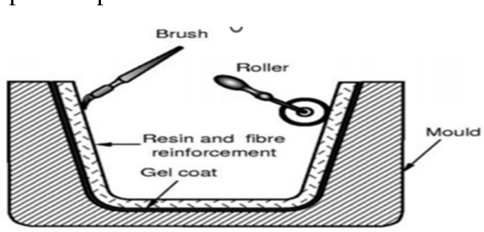
Sample preparation

Hand lay-up technique

Hand lay-up technique is the oldest method of woven composite manufacturing. The samples are prepared by respecting some steps. First of all, the mold surface is treated by release antiadhesive agent (wax+ anti mould releasing agent) to avoid the sticking of polymer to the surface.

Hand lay up process

Then, a thin plastic sheet is applied at the top and bottom of the mold plate to get a smooth surface of the product. The layers of woven reinforcement are cut to required shapes and placed on the surface of the mold.



2.4 Mould preparation

Number of samples.	Tensile strength
T_3	292.078
T_4	322.002

Thus, as previously mentioned, the resin mixed with other ingredients and infused onto the surface of reinforcement already positioned in the mold using a help brush to uniformly spread it. And then the other mats are placed on the preceding polymer layer and pressured using a roller to remove any trapped air bubbles and the excess of polymer as well.
The mold is then closed and pressure is released to obtain a single mat.
After curing at room temperature, the mold is opened and the woven composite is removed from the mold surface.

B. Procedure

- First, we have prepared a mould having the dimension of 300×300×3mm.
- Similarly prepare the e glass and basalt cut it to same 300×300 mm for e glass and for basalt 300×300.
- Prepare the resin about weight 190.86g for sample-1 8 layers
- For sample-2 6 layers resin weight 222.
- Mix resin, hardener and accelerator about the ratio 100:1.5,100:1 respectively.
- In mould place Teflon sheet apply wax and anti mould releasing agent on it.
- place it on the mould perfectly with no air gaps.
- Now pour the mixed resin into Teflon sheet spread it equally on the sides and entire Teflon uniformly.
- now place the basalt fiber on it roller it uniformly by applying air gun on it.
- Now pour resin on it and spread it equally on it.
- Now place e glass fiber on it and with the help of roller roll it uniformly.
- Repeat the same process to the 2 samples.
- One for 6 layers and another for 8 layers.

2.5 pour the resin

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2.6 resin mixture

III. TEST AND ANALYSIS

1) Tensile strength sample-1

3.1 Before Tensile test results

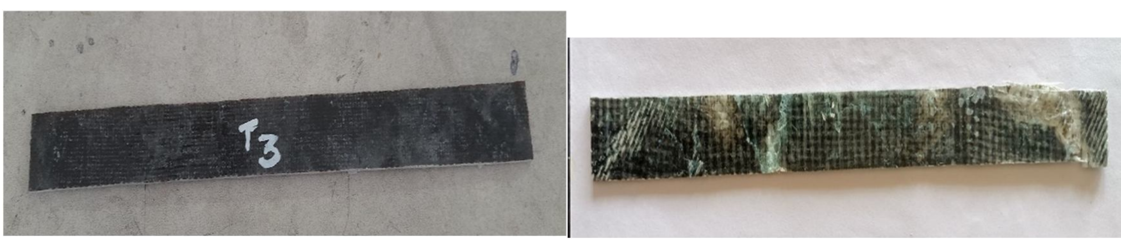


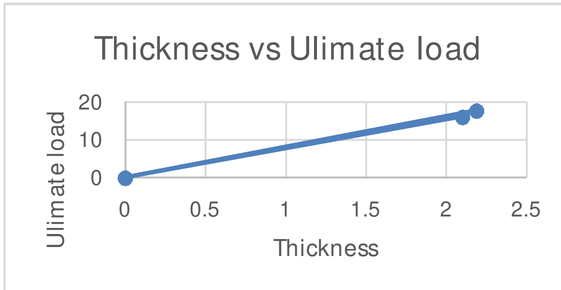
Fig-3.2 After tensile test

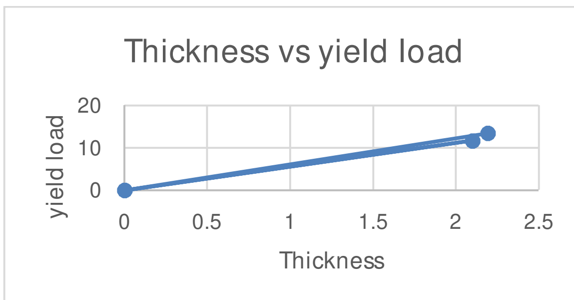
2) Tensile strength sample-2

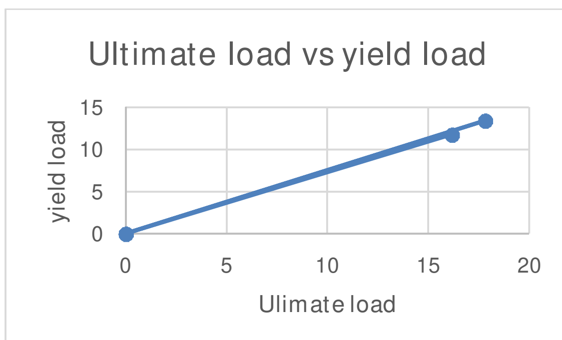
T_4[Sample-2]: The test was conducted at KVS Metallurgical labs at date 30/04/24.
Time at 2'O Clock at noon test was conducted at the room temperature 27°C.
The equipment used for conducting this test is universal testing machine (TUF-C-400,2021/31).

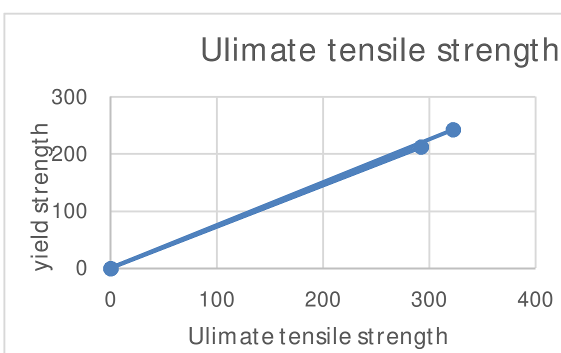
Comparision of T_1 AND T_2

Comparision of T_1 AND T_2 graphs









Flexural test

ASTM Standard

The specimen was prepared for the flexural tests as per ASTM D790 standard size of 127mm long 12.7mm wide and 3mm thickness and the flexural properties were obtained by using universal testing machined.

The flexural strength was recorded for all specimens.

Procedure

Turn the specimen on its side with respect to its position when molded, and center it on the supporting bearing blocks. The load-applying block shall be brought in contact with the upper surface at the center line between the supports. Bring load applying block in full contact with the beam surface by applying a 100lbs. (3.1 N) preload. Check to ensure that the beam is in uniform contact with the bearing blocks and the load applying block. If load is applied with a hand pump, load the beam by applying the load at a rate of one full pump stroke per second. When the applied load is about 4,000 lbs. (125 N), reduce the full pump stroke to about a 12-pump stroke and maintain the one second stroke rate. Rate of load application for screw power machines, with the moving head operating at 0.05 in.(1.3mm) per minute when the machine is running idle, is acceptable Flexural strength.

Calculations

the modulus of rupture is calculated as follows:

$$R = 3FL/(2BD^2)$$

where: R- Modulus of rupture in psi or MPa.

F-Maximum applied load indicated by the testing machine.

1-Span length in inches or mm average width of specimen in inches or mm.

Analysis

A flexural test was performed according to standard ASTM D790 that employ three-point loading system applied to a simply supported beam with the strain limit of the test at 5.0% flexural test performed at specimen room temperature, according to the standard ASTM D790 using universal testing machine (TUF-C-400). the dimensions of each sample were 127×12.7×3.

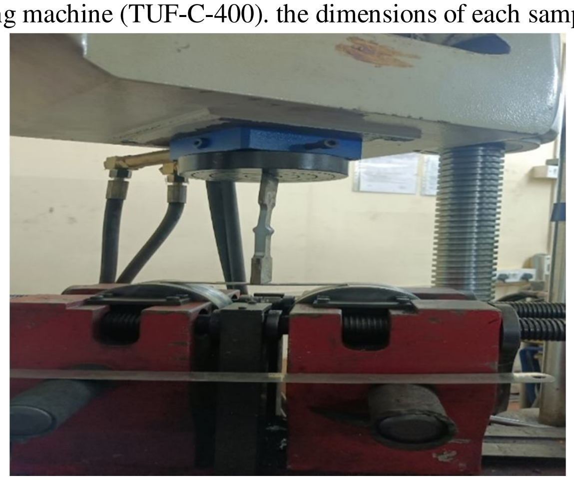


Fig-3.3 Flexural test.

Test	Test result
Width in (mm).	14.16mm
Thickness (mm).	2.26mm
Load in (Newtons).	66N
Length of supported(mm).	40mm
Flexural strength(N/mm^2).	54.75N/mm^2

F_3 [Sample-1]
The test was conducted at KVS Metallurgical labs at date 30/04/24.
Time at 2:30 at noon. test was conducted at the room temperature 27°C.
The equipment used for conducting this test is universal testing machine (TUF-C-400,2021/31).
Used formula:

$$\sigma = 3FL/(2bd^2)$$

The results of flexural test for F-3.
Before

After

Flexural test sample
Fig-3.4 sample

Test Result

Test	Test result
Width in (mm).	13.87mm
Thickness (mm).	2.63mm
Load in (Newtons).	208N
Length of supported(mm).	40mm
Flexural strength(N/mm^2).	130.085N/m^2

F_4 [Sample-2]
The test was conducted at KVS Metallurgical labs at date 30/04/24.
Time at 2:30 at noon. Test was conducted at the room temperature 27°C.
The equipment used for conducting this test is universal testing machine(TUF-C-400,2021/31).
Used formula:

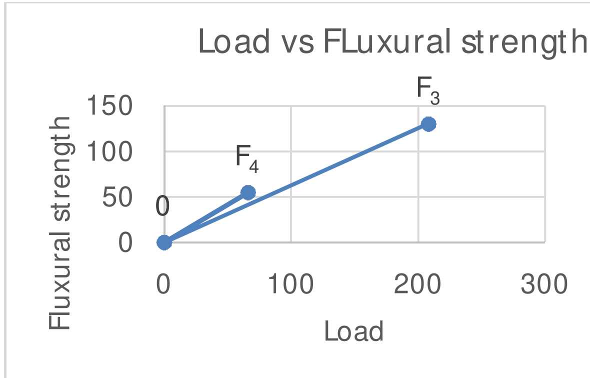
$$\sigma = 3FL/(2bd^2)$$

The results of flexural test for F -4.
Test result
Comparision Of Flexural Test Result:

Number of layers	Flexural strength
F_3	130.08
F_4	54.75

Comparison of flexural test

f_3 and f_4



Impact test

Izod Impact Test

In the Izod impact test, the test piece is a cantilever, clamped upright in an anvil, with a V-notch at the level of the top of the clamp. The test piece is hit by a striker carried on a pendulum which is allowed to fall freely from a fixed height, to give a blow of 120 energy. After fracturing the test piece, the height to which the pendulum rises is recorded by a slave friction pointer mounted on the dial, from which the absorbed energy amount Charpy Impact Test:

The principle of the test differs from that of the Izod test in that the test piece is tested as a beam supported at each end; a notch is cut across the middle of one face, and the striker hits the opposite face directly behind the notch. When the results of a number of tests performed in different temperatures are plotted, ductile-to-britile transition curves.

Number of layers.	Impact strength
I_3	6 joules
I_4	6 joules

IMPACT TEST

The test was conducted at KVS Metallurgical labs at date 30/04/24.

Time at 3'o clock at noon. test was conducted at the room temperature 27°C.

The equipment used for conducting this test is impact testing machine& FIE (Izod test).

Test Result

Before Impact Test

Fig-3.5 Impact Sample

Fig-3.6 impact sample after test

IV. CONCLUSION

In this project, we investigated the mechanical properties of composite materials composed of basalt fiber, E-glass fiber, unsaturated polyester resin, and an accelerator(cobalt). Two samples were fabricated with different resin concentrations and layer arrangements to evaluate their performance under various mechanical tests including tensile, flexural, and impact (Izod) tests.

Key Findings

Resin Content and Mechanical Strength

T-2, with a higher resin percentage of 71.52%, showed superior performance in most mechanical tests compared to Sample 1 which had only 61.47% resin.

Specifically, in the tensile test, Sample 2 exhibited a higher ultimate load (17.820 kN compared to 16.156 KN) and ultimate tensile strength (UTS) of 322.002 MPa, significantly higher than the 292.078 MPa of Sample 1.

Layer Influence

Sample 2, which contains 6 layers, demonstrated dramatically improved flexural strength (130.085 MPa) compared to the 54.74 MPa of the 8-layer Sample 1.

This indicates that increasing the number of layers positively correlates with the flexural strength of the composite material.

Consistency in Impact Resistance

Both samples showed the same impact resistance with values of 6 joules, suggesting that variations in resin content and layer count did not significantly influence the impact strength under the conditions tested.

Implications

These findings highlight the critical role of resin content and layering in enhancing the mechanical properties of composite materials. Higher resin percentages and increased layering enhance tensile and flexural strengths, offering potential guidelines for optimizing composite material design for structural applications requiring high strength and rigidity.

V. RECOMMENDATIONS FOR FUTURE WORK

Further studies should explore the impact of different types of fibers and matrix materials, as well as the orientation of the layers, to fully understand their effects on the mechanical properties of composites. This could lead to better-tailored materials for specific applications.

This project successfully demonstrates the potential of using tailored fiber and resin compositions to create composites with desirable mechanical properties suitable for various industrial applications.

REFERENCES

[1] "Application of Polymer Based Composite Materials in Transportation" by Anna G. Koniuszewska, J. W. Kaczmar provides a summary of the latest applications of fiber-reinforced polymer matrix composites in industries such as aerospace, automotive, marine, military and sport and leisure (Koniuszewska & Kaczmar, 2016).

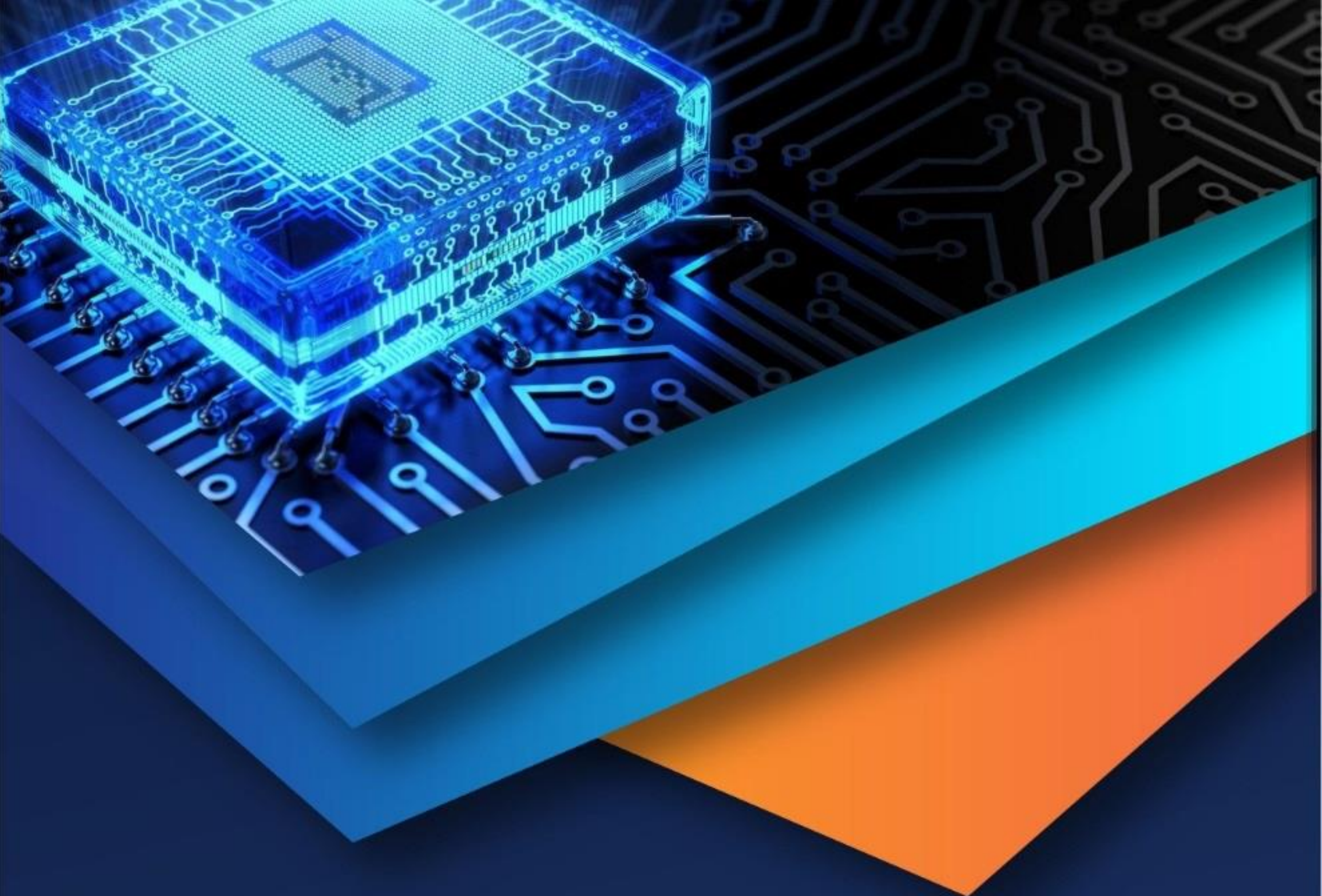
[2] Influence of curing agents on gelation and exotherm behaviour of an unsaturated polyester resin: This study investigates the effects of initiators like MEKP and promoters like cobalt salts on the curing behavior of unsaturated polyester resin used in composites (Kuppusamy & Neogi, 2013).

[3] The surface properties of precipitated and calcined cobalt oxide" by K. T. Chisnall, Jacques Lucas, K. S. W. Sing (Chisnall et al., 1965).

[4] T.Manikanatan et al study the thermal and mechanical properties of basalt fibers Published at 2021.

[5] M. Lombardi et al. (2018),This research focused on the durability of basalt fibers in alkaline environments, which is a critical factor for their use in concrete and other composite materials.

[6] B.Singh focused on cost effectiveness and overall performance of basalt and e glass.
[7] C. Wei et al. (2019) The study by Wei and colleagues analyzed the impact of E-Glass fibers on the properties of polymer composites.
[8] J. H. Park et al. (2020), This study explored the recyclability of E-Glass fibers and their environmental impacts. The results suggest that while E-Glass fibers can be recycled, the process is energy-intensive, raising concerns regarding its ecological footprint.



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