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Investigation on Morphological and Thermal Behaviour of Hybrid Composite with Graphene and Boron Carbide Nano Fillers

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ABSTRACT

This paper gives an investigation into the morphological analysis of boron carbide and thermal properties of the Jutton-Glass hybrid polymer nano composite used in marine applications. As reinforcements, hybrid nanoparticles comprising of boron carbide and graphene nano platelets were used. For laying the composites, the vacuum bagging technique was used with the composition of hybrid nano-material taken as 0, 0.25, 0.5 and 1 wt. % of Gr and B4C and the samples were testing for thermal properties as per ASTM standards. The samples prepared have been subjected to various testing's and the results are reported. Prior to the preparations of composites, the polymer is mixed with surface modified nanomaterial and stability tests were conducted to assess uniform dispersion the aid of U.V. spectroscopy, and the outcomes showed that the samples had been exceptionally uniform over a period of time. It is determined that the thermal behaviour of hybrid composites, which include 1% B4C and Gr, shows more improved properties than base. But the multi-layered samples with 0.5% Gr and B4C also showcased encouraging properties like thermal conductivity, thermal effusivity, specific heat, thermal resistance and thermal diffusivity. This paper presents an overview of thermal properties and use of polymer matrix composites in the marine industry

KEYWORDS - Stability, Boron Carbide (B4C), Scanning Electron Microscopy (SEM), Morphological Analysis, Thermal Properties, Marine applications.

1. INTRODUCTION

The growth of composites and their applications in manufacturing is a brilliant development in the history of materials. Composites are used in numerous fields with mechanical and biological backgrounds for unique applications. When two or more materials with different properties are mixed, a composite material is created. The presence of particles in a composite material adds to its mechanical properties, which include hardness, tensile and flexural strength. Depending on the type of matrix, composites can be categorized into 3 types: Metal matrix composites, ceramic matrix composites, and polymer matrix composites. Especially in the marine sector, polymer matrix composites are used in the construction of marine vehicles (ships, boats, yachts, etc.) and equipment. Marine systems and structures include the hull and shipbuilding industries (ship and submarine masts, propellers, and interior parts), the offshore applications industry (gas pipelines, tendons, and support structures), and the renewable energy sector (turbine devices and rotor blades). The importance of lightweight design is increasing day by day in vehicles used in land, air, and sea transportation. Today, the increase in the value of both safety and energy savings causes research on composite materials to intensify in the marine sector. It is advantageous to use composite materials in many parts so that negative environmental effects such as corrosion, biological pollution, seawater aging, and hydrostatic pressure cause minimal damage to marine structures. With the developments in composite science, the level of use of these materials is increasing in the marine sector, as in every other field.

1.1 About polymer composites:

Polymer matrix composites (PMCs) are composite materials in which a polymer matrix is strengthened by including high-strength fibers or particulate elements. The incorporation of the polymer matrix and reinforcing materials yields a composite material that demonstrates improved mechanical, thermal, and occasionally electrical characteristics in comparison to the separate constituents. The properties of polymer matrix composites are determined by three constitutive factors: the type of reinforcements (particles and fibers), the type of polymer and the interface between them. Nowadays, these composites are used in various sectors such as automotive, marine, aerospace and many others due to their high specific stiffness and strength.

Fiber-polymer composites, also known as fiber-reinforced polymer (FRP) composites, are composite materials consisting of a polymer matrix reinforced with high-strength fibers. These composites combine the favorable properties of both the polymer matrix and the reinforcing fibers, resulting in materials with enhanced mechanical, thermal, and sometimes electrical characteristics.

A fiber is characterised by the fact that its length is much greater compared to its cross-sectional dimensions. The properties of the matrix, the fiber and its interface significantly influence the properties of composites. Fibers in polymer composites can be either synthetic/man-made fibers or natural fibers. Commonly used synthetic fibers for composites include glass, aramid, carbon fibers, etc., while natural fibers include jute, banana, cotton, flax, hemp, etc. Depending on the application, there are different types of glass fibers, e.g. E-glass fibers for electrical applications, C-glass for corrosive environments and S-glass for structural applications and high temperatures. Glass fibers are available in various forms, including continuous fibers, chopped fibers and woven fibers. When the fibers are derived from natural sources such as plants or other living organisms, they are referred to as natural fibers.

The properties of some of these fibers can be found in Table 1. Composites made from the same reinforcing material may not perform better because they are exposed to different loading conditions during their lifetime. To solve this problem, hybrid composites are the best solution for such applications. A hybrid composite material is a combination of two or more different fiber types, where one fiber type compensates for the deficiency of another fiber type. The concept of hybridization offers the designer the flexibility to tailor the material properties according to the requirements.

1.2 Nano-composites:

Fiber-reinforced polymer nanocomposites (FRPNCs) are a sophisticated type of composite materials in which durable fibers are incorporated into a polymer matrix that is additionally strengthened with nanoscale fillers or nanoparticles. The utilization of both macroscopic reinforcement (fibers) and nanoscale reinforcement (nanoparticles) enables the augmentation of mechanical, thermal, and barrier properties to a greater extent than what can be achieved with traditional fiber-reinforced polymer composites. These composites can be categorized as unintercalated, interposed, exfoliated, and are produced using various techniques such as intercalation of polymer, in-situ polymerization, and melt compounding. Biomedical Nano-composites are specifically designed for dental treatments, bone tissue engineering, and drug delivery in cancer treatments and wound dressings. Moreover, the optical properties of composite materials can be improved by embedding a transparent matrix material. Certain Nano-composites, including CNTs, Graphene and its oxides, and MoS2/Graphene, have shown promising optoelectronic properties for photonic applications.

Table 1. Physical properties of various fibers.

Type of Fiber	Tensile strength (MPa)	Young's modulus (GPa)	Elongation at break (%)	Density (g/cm^3)
Megass	292	17.5	----	1.26
Willow	221	11.5-18.2	-----	0.61-1.12
Musa Paradisiac	501	13.2	5.93	2.32
Coir	178	4.4-8.1	30.5	1.21
Gossypium	564	5.52-13.63	8.1-9.2	1.41-1.62
Linum	1039	28.62	2.72-3.32	1.52
Cannabis	690	73.1	1.61	1.47
Corchorus	392-778	26.52	1.51-1.82	1.20
Hibiscus Cannabinus	935	53.5	1.62	----
Agave Sisalana	521-643	9.41-23.1	2.1-2.51	1.61
E-glass	3412	73.4	------	2.51

Graphene:

Graphene is an allotrope of carbon, composed of hexagonally arranged carbon atoms in a layered structure. A single layer of carbon atoms isolated from the bulk graphite structure is called "graphene". The carbon atoms in a graphene layer form three robust in-aircraft bonds per atom, which in turn ends in the formation of a hexagonal planar layer with a honeycomb-like atomic association.

Boron Carbide:

B_4C possesses a range of notable properties, including a high melting point, a high hardness, a low density, exceptional deterioration and rusting confrontation, and more. Currently, this material is garnering significant attention in the field of nano-composites research owing to its distinct somatic, chemical, and electric characteristics, which position it as a foremost challenger amongst the constituents with potential for high performance applications [53–65]. The micro-sized performance applications [53–65]. The micro-sized boron carbide powder is sourced from a specialized supplier and subsequently transformed into nano-sized particles.

1.2.1 Study on natural Fiber based Polymer Composites:

Natural-based polymer composites have been used more frequently in recent years because of their many benefits, including biodegradability, flexibility, availability, affordability, and light-weight nature. Many studies have been carried out by researchers to improve the mechanical properties of these composites. Gowda et al., for instance, found that composites made of jute fibers have stronger properties than those made of wood. In unsaturated polyester resin, Chawla and Bastos investigated the impact of fiber volume fraction on the mechanical characteristics of untreated jute fibers. According to Schneider and Karmaker[], composites made with jute fibers have better mechanical qualities than those made with kenaf fibers.

1.2.2. Study on non-natural Fiber based Polymer Composites:

A significant extent of research has been conducted by numerous researchers on polymer composites based on artificial fibers. *Huang et al.*(20) investigated the impact of water absorption on the mechanical properties of glass/polyester composites. It was determined that the breaking strength and tensile strain of the composites gradually decreased with increased immersion time in water, as the bonding between the fiber and matrix weakened. *Yuan et al. (21)* examined the reinforcing effects of modified jute fiber on the mechanical properties of timber-flour/polypropylene composites and discovered that the addition of Kevlar fiber enhanced the mechanical trends of the materials. Wang et al.'s studies (22) into the mechanical traits of composites strengthened with woven Kevlar and fiberglass found that the sort of fiber utilized had a great impact on the fibers mechanical behavior. At the same time as Cho et al. (23) seemed into the mechanical conduct of carbon fiber/epoxy composites, they discovered that the composites reinforced with nanoparticles had better mechanical traits, along with better shear and compressive strengths.

1.2.3 Impression on Hybrid Fiber based Polymer Combinations:

Hybrid fiber composites are composed of a mixture of natural and/or synthetic fibers, that may encompass highly-priced materials including glass, carbon, and boron fibers. Several studies have examined the mechanical behaviour of hybrid composites based on different fiber combinations, along with jute and oil palm fiber or glass and jute. Those investigations have proven that using hybrid structures can effectively beautify the tensile and dynamic mechanical performance of composites because of stepped forward fiber/matrix interface bonding. Moreover, remedies such as the conduct of jute cloth were determined to enhance the performance characteristics. Notch sensitivity has also been studied in untreated woven jute and jute-glass cloth reinforced polyester hybrid composites, with jute composites showing higher sensitivity than jute-glass hybrids. The impact of stacking sequence on mechanical features has additionally been experimentally investigated in interlaced jute and glass material bolstered polyester hybrid composites.

1.2.4.Dispersion of Nanomaterials in polymer:

Achieving uniform dispersion of nanoparticles within the polymer matrix is crucial. Agglomeration of nanoparticles can lead to uneven properties and compromise the performance of the nanocomposite. Modifying or functionalizing nanoparticles on the surface can increase their stability in the polymer, leading to better dispersion. The compatibility of nanomaterials with the polymer matrix can be improved by applying surface treatments or coatings. This is achieved by utilizing surfactants, coupling agents, or other chemical treatments to alter the surface energy and facilitate greater dispersion. These agents can help stabilize the nanomaterials in the polymer matrix and prevent agglomeration. The dispersion stability of nanomaterial's in the polymer prior to preparation of fiber reinforced polymer nanocomposites is a vital step. To assess the stability, UV Visual spectroscopy is normally employed.

1.3 **Present work and Novelty:**

This research aims to examine the investigation, evaluation, and thermal behaviour of jutton/glass fiber-strengthened epoxy hybrid composites with Nano fillers such as graphene and boron carbide. The study investigates the impact of B_4C size, with and without surface modification, on thermal properties. Additionally, the morphological and thermal behaviour as well as the stability of the composite polymer were analysed using micrographs. Jutton fibers offer several benefits, including improved performance, enhanced durability, and thermal resistance, quick drying, reduced shrinkage, and cost efficiency.

2 Materials and Methods:

This phase provides an overview of the processing information for the composites and the experimental procedures conducted to characterize and test the composite specimens. The raw materials utilized in this study are

- **2.1 Materials:**

Reinforcements / fibers: Jutton fibers (Jute + Cotton), Glass fiber

Matrix / Resin: Epoxy (LY556) with hardener (Hy951)

Nano-fillers: Boron Carbide, Graphene

Type of method: Stability, Surface modification.

Fabrication Technique: Vacuum Bagging Technique

The bast fiber with the highest production extent is jute, which is likewise one of the most low-cost natural fibers. Jute plants can grow up to 2–3.5 m in height; however, their fibers are brittle and feature low extension to break due to their high lignin content material (12–16%). However, jute fibers have less resistance to moisture, acid, and UV light. On the other hand, cotton fibers are soft, cool, and can hold water 24-27 times their own weight. They are also resistant to abrasion, wear, and high temperatures. A visual representation of diverse varieties of jute fibers is shown in the figure.

Fig:1. 50:50 Jute and Cotton Fiber (Jutton fiber)

Jutton fibers are acquired from plant life and are a mixed form that comprises fibers of jute and cotton. At present, in the jute sector, it has been used and improved to a satisfactory level for use in diverse regions, particularly ground coverings, technical textiles, household textiles, handicrafts, etc. It emphasizes combining and growing the best qualities while at the same time minimizing the wicked qualities of the fibers. Mixing jute with cotton fiber may be an acceptable process of jute diversification, with the aid of which value-added merchandise may be produced. As a result, the techniques of softening and mixing have established a new class of jutton-based products. S2 Glass offers substantially greater power than conventional glass fiber, better fiber durability, modulus of resistance, impact deformation, and green processing. This has the capacity of composite parts to face up to high stages of concern and flexural fatigue. Epoxy LY556 is Araldite LY556 is a medium-viscosity, unmodified epoxy base on bisphenol-A. It possesses tremendous mechanical properties and resistance to chemical compounds, which can be modified within wide limits by way of the use of HY951 hardener as well as fillers. Epoxy LY556, which specifies LY as bisphenol-A, and 556 is a five-vicosity code, five-performance grade. 6-curing time(seconds).

Nature of Epoxy resin LY-556:

1.Visual issue - self-evident, light yellow fluid

2. Viscosity@ 250 C - 10000-12000 MPa

3. Thickness , 250 C - 1.15-1.20 gm/cm3

4. Streak factor - 1950 C

What's more, hardener HY951 which indicates HY as Araldite and 951 is nine-thickness code,5-execution code,1-relieving time(in seconds). homes of hardener HY-951:

1. Thickness = 0.95 gm/cm3

2. Liquefying factor = 120 C (lit.)

3. Edge of boiling over = 266-2670 C (lit.)

4. Water solubility= Dissolvable

5. Streak point = 143.330C

2.2 Characterization:

2.2.1 Scanning-Electron-Microscopy (SEM)

It is used to study the morphological characterization of the composite and powder particles. SEM images have been taken of synthesized boron carbide during the milling process, with variations in timing. As the dimensions of the matters approached the nanoscale and the percentage of fragments on the surface decreased relative to the total number of molecules, the properties of the substances changed. The figure shows smaller, more uniform, spherical particles, as well as heavily agglomerated debris within the powder.

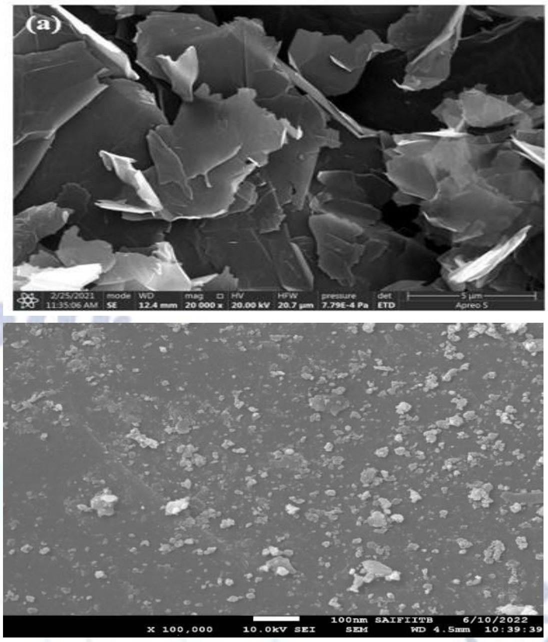

Fig.2.FESEM images of a) graphene b) B4C nano

2.2.1 Surface modification:

The hybrid composites [14, 22] have been extensively studied and it has been found that the composites with a jutton-to-glass ratio of 3:2 exhibit superior thermal properties, including thermal conductivity and thermal effusivity, compared to untreated jutton composites. To further enhance these properties, the jutton and glass fibers are exposed under varying intensities of UV radiation. The UV-pre-treated jutton and glass fiber (3:2) composite, at the most optimal intensities, demonstrates the highest thermal properties when compared to untreated jutton and glass-based hybrid composites.

2.3 Preparation of the Composite

2.3.1 Preparation of polymer and its stability:

The stability of polymer dispersed with nanomaterials as reinforcements is a crucial aspect that determines the performance of nanocomposites and their suitability for various applications. Proper dispersion of nanofillers within the polymer matrix is crucial. The clustering of nanoparticles can result in non-uniform characteristics and jeopardize the stability of the nanocomposite. Methods such as sonication and melt mixing are frequently used to attain homogeneous dispersion. The resilience of the interface between the polymer matrix and nanofillers is crucial during the creation of nanocomposites. Enhancing the interfacial adhesion between the matrix and the filler is crucial for effectively transferring stress, hence enhancing the mechanical characteristics and stability of nanomaterials. The ultra-sonication technique affects the surface and structure of nanoparticles and prevents the agglomeration of particles to form solid fluids. Adequate dispersion of short Jutton-glass fibers in a resin can be achieved without sonication. However, due to the clinginess of graphene and boron carbide, the degree of dispersion of graphene and B_4C in the resin mixture can be improved by sonicating a suspension of nanoparticles. The reasonable dispersion is much greater and effects the size of the nanopowder agglomerates.

2.3.2 Assessment of stability of polymer dispersed with nanomaterials

To assess the stability, UV Visual spectroscopy is normally employed. UV-Visible (UV-Vis) spectroscopy is a method employed to evaluate the durability of nanoparticles in polymers before creating polymer nanocomposites. UV-Vis spectra are collected in order to observe any alterations in the absorption characteristics of the polymer that is distributed with nanoparticles. The UV stability assessment primarily focuses on the UV range, which spans from 200 to 400 nm. UV-Vis spectra can detect absorption bands linked to the polymer and nanomaterials included within it. Alterations in these bands can signify the clustering and sedimentation of nanomaterials. Prior to subjecting the polymer dispersed with nanoparticles to UV radiation, a baseline UV-Vis spectra of the parent polymer is acquired. This spectrum functions as a benchmark for comparison and aids in the detection of any alterations in the absorption properties of the material.

2.3.3 Preparation of composite with vacuum bag method:

Vacuum bag molding is a highly effective technique utilized in composite manufacturing to produce laminated structures. This technique applies pressure to the laminate throughout its action cycle, serving various purposes.

- Efficiently removes any trapped air among the layers of fabric.
- Compacts the layers of fibers, ensuring sturdy bonding between them and preventing any distortion at some stage in the preparation system.
- Facilitates reducing humidity ranges.
- And most importantly, the vacuum bagging technique complements the integration of the fiber and resin in the composite.

The key to accomplishing those advantages lies in maximizing the ratio of fiber to resin. It is vital to observe that the reinforcement within the fabric industry. Moreover, thermosetting resins like polyester and epoxy can end up brittle if they're not properly strengthened in the course of the curing process. If there is extra resin inside the laminate, it'll showcase extra habitations of the resin as opposed to the desired composite. Conversely, if there is too little resin, areas in which the reinforcement is dry will have susceptible spots. To optimize the resin content, it is essential to absolutely saturate the entire reinforcement with resin while minimizing any excess content. The essential principle in the back of the vacuum bagging technique is to "squeeze out" any excess resin so as to obtain a maximized fiber-to-resin ratio.

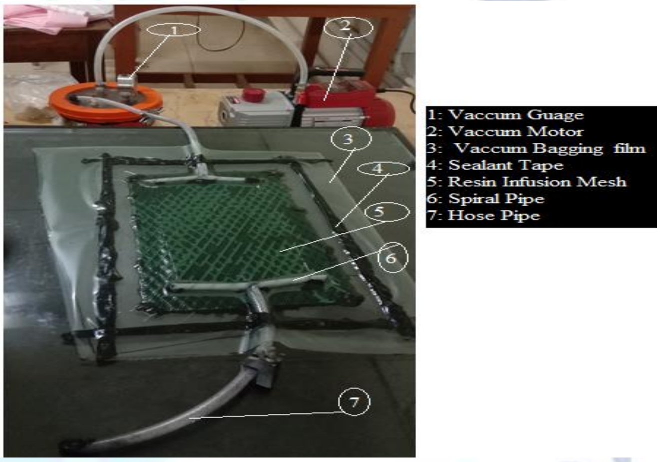

Fig:3. Experimental Setup

2.4 Thermal properties:

Numerous studies on thermal properties of different polymer nano composites have already been conducted in the last decade but investigations on melting temperature, glass transition temperature, thermal conductivity, and thermal expansion coefficient of the nano composites were found to be most pivotal.

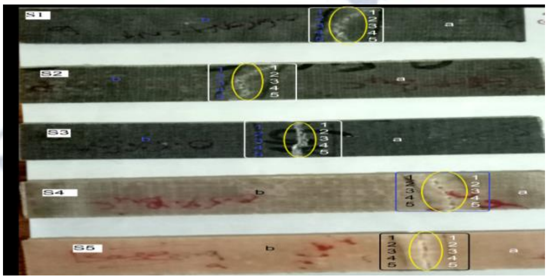

Fig:4 Composite Specimens

a. **Thermal conductivity (K) :**

The thermal conductivity is commonly the transfer of thermal energy through any material. Higher thermal conductivity materials have been applied in heat sinks, whereas materials of lower thermal conductivity are utilized for insulation applications. The dissipation of thermal energy is essential to regulate the life, reliability, and functioning of the materials. Theoretical and fundamental investigations have been performed to exhibit the principle of thermal conductivity on both significant and macroscopic scales. In polymer based nano composites, thermal conductivity mainly based on the characteristics of the nanoparticle and polymer resin. The pure polymers generally have a lower value of thermal conductivity. The various factors affect the heat conduction of materials such as type of polymer matrix (thermosetting/thermoplastic), polymer/nanoparticle interface, crystallinity, and miscibility.

The thermal conductivity of polymer and their respective composites is generally improved under a lower concentration of nanoparticle loading. In the polymer-based nano-composites, nanoparticles can produce thermal conduction with uniform nanoparticle dispersion and orientation. The sparse distribution and accumulation of nanoparticles may create thermal protection, restricted to thermal conductivity enhancement. The nonspherical-sized nanofillers such as nanorods, nanotubes, or nanoplates can be uniformly oriented and dispersed, which tends to higher thermal conductivity. Various nanoparticles, such as graphene, CNT, graphite, nanodiamond,B4C and so on have been utilized to improve the thermal conductivity of the polymer-based nanomaterials. The thermal conductivity value for various polymers is generally lower and ranges between 0.1 and 0.8 W/mK.. It is experimentally obtained by c-therm at different temperatures of the samples.

b. Thermal Effusivity(e) and Diffusivity (α):

The thermal diffusivity and effusivity are both composite material properties that contain the qualities: density, conductivity and specific heat capacity. The thermal effusivity is a measure of a materials ability to exchange thermal energy with its surroundings. Thermal effusivity (also known as thermal inertia) describes the heat storing or dissipating capacity of a given material and has units of ($Ws^{½}/m^2K$). It is used to describe the one-dimensional heat transmission between two closely associated and touching objects. Even if two different materials are at the same ambient temperature, the material with the higher thermal effusivity will “feel cooler” and the material with the lower effusivity will “feel warmer” to the touch. The thermal diffusivity of a material is a measure of how fast the material temperature adapts to the surrounding temperature.

Table:2 Thermal property values for for composite

Sample /Properties	Therm.Conduc(K) in w/m-k	Therm.Effusiv(e) in $Ws^{½}/m^2$-K	Sp. Heat (C_p) in j/kg-k	Therm.Resis. (R_a) in kg-k /j	Therm. Diffus. (α)in m^2/s
Base	0.2532	0.8333	8.0331	1.4986	0.0174
0.25% [Gr+B4C]	0.4502	1.08333	5.52727	1.92466	0.028264
0.5% [Gr+B4C]	0.6891	2.16905	3.42833	3.2351	0.04475
1% [Gr+B4C]	0.7985	4.3381	2.5781	4.1264	0.0844

3 Results and Discussion:

The obtained solid laminates are cut as per ASTM standards, and various characteristics are being analyzed. Stability tests for the resin samples with various volume percentages of nanoparticles were performed, and the results were analysed

3.1 Polymer and its Stability:

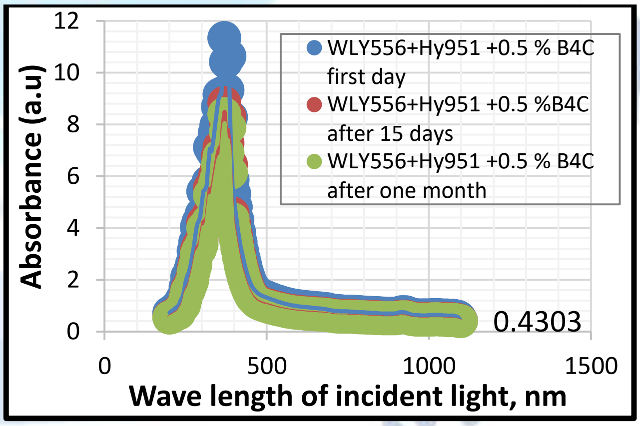

Fig.5 Absorbance vs. Wavelength of incident light

Figure 5 shows the absorbance vs. wavelength of incident light of the epoxy-B4C substance. If the wavelength of incident light increases, the absorbance in the respective substance reaches its maximum value and then decreases as shown in table 3.

Table:3 Peak Absorbance

S.No	No.of Days	Peak Absorbance(a.u)
1	1st Day	11.345
2	After 15 Days	8.845
3	After One month	8.403

3.2: Thermal Properties on Composite Specimen:

3.2.1 Thermal conductivity:

The thermal conductivity test was performed randomly on the surface of each sample, and mean values are reported. Thermal conductivity is found for different samples at various temperatures. Fig.6, shows the relation between thermal conductivity and samples. It is concluded that the sample 1% ($Gr+B_4C$) exhibits highest thermal conductivity i.e., K=0.7985w/m-k and base sample is exhibiting lowest thermal conductivity i.e., K=0.2532w/m-k due to the lack of nano particles. The values of thermal property values for composite specimen are shown in Table 3.

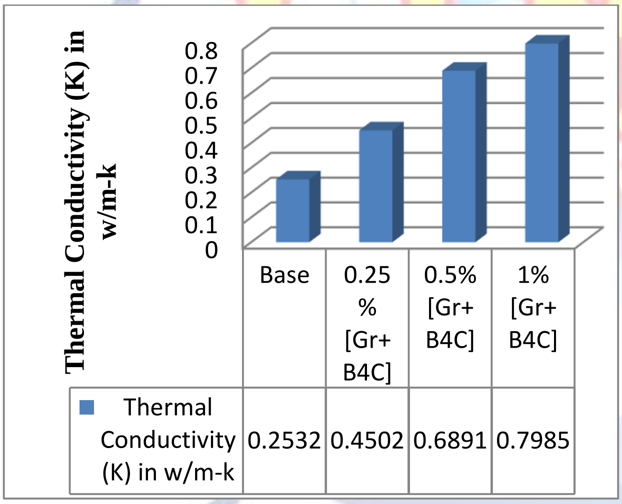

Fig.6: Thermal conductivity for various samples

3.2.2 Thermal Effusivity (e) :

The thermal effusivity test was performed randomly on the surface of each sample, and mean values are reported. Thermal effusivity is found for different samples at various temperatures. Fig.7, shows the relation between thermal effusivity and samples. It is concluded that the sample base exhibits lowest thermal effusivity i.e., e=0.8333 Ws½ /m²-K and 1% ($Gr+B_4C$) sample is exhibiting highest thermal effusivity i.e., e=4.3381 Ws½ /m²-K due to the lack of nano particles.

The values of thermal property values for composite specimen are shown in Table 3.

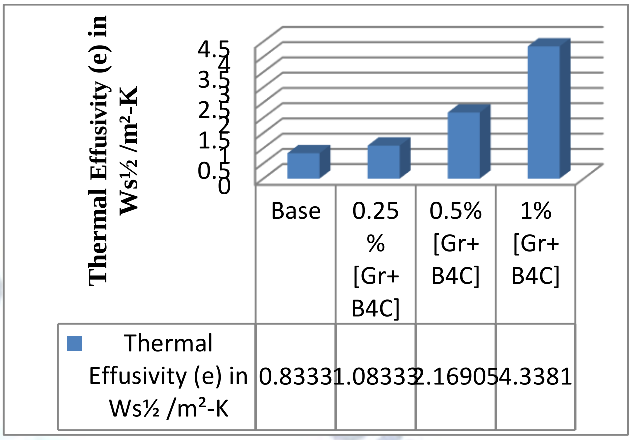

Fig:7 Thermal Effusivity for various composite

3.2.3 Specific Heat (Cp):

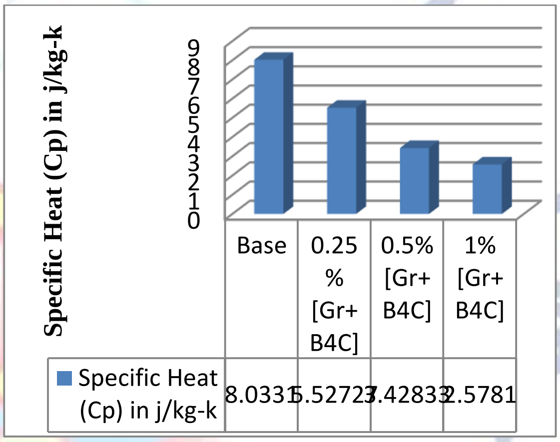

Fig.:8 Specific Heat of composites

Fig. 8 shows the relation of specific heat and samples. In this, it is evident that the specific heat of the 1% ($Gr+B_4C$) sample has decreased at a greater rate. The sample 1% B_4C+Gr has attained the lowest value of 2.5781 j/kg-k in comparison with other samples.

3.2.4 Thermal Resistance (R_a):

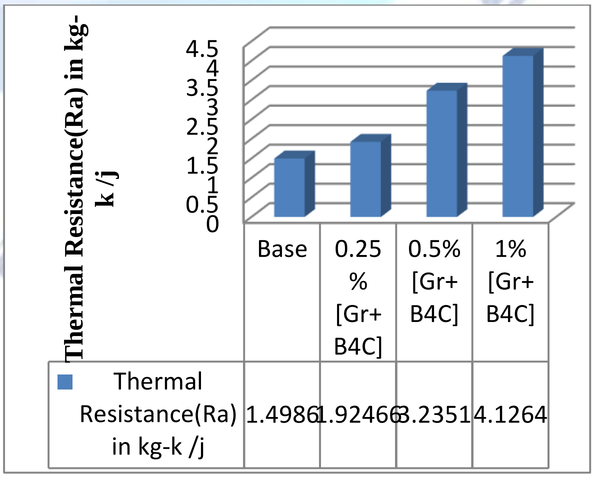

Fig:9 Thermal Resistance for composite samples

The addition of Gr and B_4C nano particles on GFRP hybrid composite, due to the strong filler / matrix and good particle dispersion, which led to an efficient thermal stress regulator, the addition of nanoparticles considerably will increase the thermal resistance of the samples. As per the results, beginning with a composite specimen without nano fillers, the thermal resistance is 1.49861kg-k/j, the sample containing 1 % B_4C+Gr shows the high thermal resistance of 4.1264 kg-k/j and further it declined as shown in fig.9.

3.2.5 : Thermal Diffusivity (α):

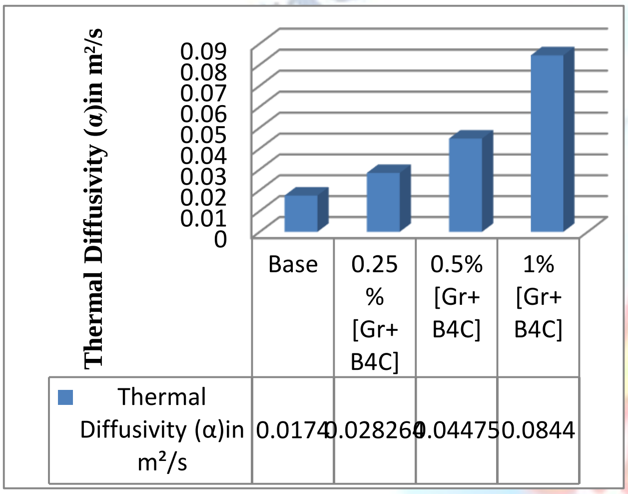

Fig:10 Thermal Diffusivity for composite

The effect of with and without surface modification of Gr and B_4C nano particles on GFRP hybrid composite is shown in Figure 10, due to the strong filler / matrix and good particle dispersion, which led to an efficient stress regulator, the addition of nanoparticles considerably will increase the thermal behaviour of composite. Subsequently, the expansion of nanoparticles essentially improves in the composite. Beginning with a composite specimen without nano- particle the thermal diffusivity is less i.e.,0.0174 m^2/s, subsequently the the nano filler is filled with Gr and B_4C in definite proportions increasingly.From the above graph the thermal diffusivity increased gradually from base to 1%Gr and B4C.

4. CONCLUSION:

This research focuses on marine applications of polymer matrix composites. Composite materials, which are used instead of traditional materials due to their many advantages, are also widely used in the marine sector. In addition, studies on hybrid composites are continuing. With the development of design, analysis, and manufacturing methods, it will be possible to manufacture more economical, reliable, and durable materials with different components. In this way, the application area of composites will increase, and their properties in the places of use will be further improved.

Based on the results and discussion, it can be concluded that

- The stability of the particles is uniform, as evidently showcased in the absorbance, i.e., if the wavelength of incident light increases, the absorbance in the respective substance reaches its maximum value and then decreases.
- Thermal properties like thermal conductivity, thermal effusivity, specific heat, thermal resistance and thermal diffusivity improved when embedded with nano fillers of Gr and B_4C.
- Thermal Effusivity, conductivity, diffusion and Resistance increase with increase percentage of Nano fillers of Gr and B_4C.
- The specific heat decrease with increase percentage of Nano powders of Gr and B_4C.
- The values of thermal Resistance at range.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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