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The Characterization of a Laminated Hybrid Composite Made of Hemp, Vinyl Ester, and Carbon Fiber That Is Reinforced with Carbon Nano Tubes

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ABSTRACT

Natural fibres derived from sustainable natural resources have recently shown promise as an alternative to glass, carbon, and other man-made fibres as a reinforcing material for polymer composites. Hemp is the most often used natural fibre because of its low density, inexpensive cost of manufacturing, and good mechanical qualities. Lightweight, strong, corrosion resistant, and close to net forms are all requirements for today's materials, and composites may help satisfy these. Two or more coupled elements, which are not soluble in each other, make up a composite material, which is a structural substance. Reinforcing phases such as fibres, particles, or flakes exist in composites, as do matrix phases such as polymers, metals, and ceramics. In this study, hemp/carbon fibre and carbon nano tube reinforcement and vinyl ester are used as matrix materials to make various composite materials. The following tests were performed on the composites: a density test, a water absorption test, and an impact test. An investigation into the influence of carbon nanotubes on hemp/vinyl ester/carbon fibre hybrid composites found that fibre loading and performance were significantly affected by the inclusion of carbon nanotubes.

The following terms and concepts are used in this paper: Hemp Fiber, Carbon Fiber, Vinyl Ester, Density, Water Absorption, and Impact.

INTRODUCTION

A major breakthrough in the history of material science occurred with the creation of composite materials and its accompanying design and production processes. Developed for specific applications, composites are materials with unique mechanical and physical characteristics. Materials have a wide variety of benefits over traditional materials, including tensile strength, impact strength, flexural strengths, stiffness, and fatigue properties. Aerospace and commercial mechanical engineering applications, such as machine components, automobiles, combustion engines, mechanical components such as drive shafts, tanks, brakes, pressure vessels and flywheels, thermal control and electronic packaging, railway coaches and aircraft structures, use them widely due to their numerous benefits. A composite material is created by mixing together two or more distinct materials, each with its own unique qualities. Reinforcement, a strong load-bearing substance, is included into the composite material (known as matrix). Reinforcing fibers/particles in a composite improve its mechanical properties such as tensile strength, flexural strength, impact strength, stiffness, etc., while the matrix's primary function is to transfer stresses and protect reinforcing fibers/particles from mechanical and/or environmental damage. Composites may be categorised in a variety of ways. Metal matrix composites, ceramic matrix composites, and polymer matrix composites may all be subdivided into three groups based on their matrix materials. Each form of composite material may be used for a variety of different purposes. Metal matrix composites are made using metals such as aluminium or copper as the matrix material. Superior electrical and thermal conductivities, as well as excellent ductility and strength, are among the characteristics of these materials. Due to the low thermal expansion coefficient of the matrix, these materials have good dimensional stability and can endure high temperatures. Reinforcements have a high elastic modulus, which gives them a high level of rigidity. Ceramic matrix composites are formed when the matrix material is ceramic. Inorganic ceramic materials include bricks, pottery, oxide, nitrides, and carbides of silicon, aluminium, zirconium, and other metals and elements. They are often nonmetallic and subjected to high temperatures during processing.

Making ceramic matrix composites has as its primary goal improving toughness, hardness, high temperature characteristics, and wear resistance, among other things. A polymer resin serves as the matrix material in polymer matrix composites, which are then filled with various reinforcements. Cheap density, strong thermal and electrical insulator, simplicity of manufacture, and low cost are only few of the benefits this kind of composite has over others. Particle and fibre reinforcement, polymer type, and interface all play a major role in determining a composite material's mechanical qualities and performance. In the polymer world, thermoplastics and thermosets are the two main types of polymers. As a general rule, thermoplastics are more ductile and robust than thermosets. Heat and pressure may be used to reshape them reversibly. Flexibility and reformability are achieved because thermoplastic molecules do not cross-link. Generally speaking, thermoplastics have a lower creep resistance than thermosets, particularly at higher temperatures. To compensate for their reduced stiffness and strength, these materials must be reinforced with fillers and other materials. A wide range of thermoplastic composite materials are available, including nylon, polyethylene, polycarbonate, Teflon and polyethylene. Nylon is the most often used thermoplastic composite material. Thermosets are materials that undergo a curing process during component production and cannot be remelted or reformed once they have been cured. Brittle in nature, thermoset materials have improved stiffness and dimensional stability, as well as increased chemical, electrical or solvent resistance. Polyester, epoxy, phenolic, vinyl ester, and polyamide resins are the most popular thermoset resins. Particulate reinforced polymer composites and fibre reinforced polymer composites may be subclassified based on the reinforcing types. A particulate composite is one in which the reinforcing material is in the shape of a particle. Reinforcing particles may be spherical, platelet-like, cubic, tetragonal, or of any other regular or irregular geometry, depending on their size and form. Random or desired particle orientation may be used in the composites. Particles are often employed in composites to adjust properties such as thermal and electrical conductivity, wear and abrasion resistance, machinability, surface hardness, shrinkage, and performance at high temperatures. The reinforcement in fibre reinforced polymer composites, or fibrous composites, is made up of fibres. Due to their high specific stiffness and strength, these composites are now being used in a variety of industries, including automotive, marine, and aerospace. In composite materials, fibres are the most essential reinforcements in the sense that they meet the necessary requirements and transmit strength to the matrix ingredient, which influences and enhances the desired qualities. The length of a fibre is much longer than its cross-sectional dimensions. Composite materials are influenced substantially by the qualities of their matrix, fibres, and interface. Polymer composites may be manufactured using synthetic or natural fibres, depending on the application. Glass, aramide, and carbon are some of the most popular synthetic fibres used in composites. Natural plant fibres are among the many. Jute/Hemp has been used for hundreds of years to make ropes, mattresses, bags, and other products. India, Bangladesh, China, Nepal, and Thailand are just a few of the nations where jute may be found in abundance. When compared to other natural fibres, it has a far higher toughness and aspect ratio. In comparison to fibres like coir, pineapple, banana, and sisal, hemp composites offer excellent impact strength and intermediate tensile and flexural characteristics.

EXPERIMENTATION

A. What you'll need to get started. Researchers' prior work informs the selection of reinforcements and the composition of their composites. The materials listed below were utilised in this project and are the same as those previously mentioned. Fibers made from hemp are: Hemp, often known as industrial hemp, is a strain of the Cannabis sativa plant that is primarily found in the northern hemisphere and cultivated particularly for the industrial usage of its derived products. Ten thousand years ago, it was one of the first plants spun into fibre, making it one of the fastest-growing plants. Paper, textiles, clothes, biodegradable plastics, paint, insulation, biodiesel, food, and animal feed may all be made from it.

Carbon fiber :A. What you'll need to get started. Researchers' prior work informs the selection of reinforcements and the composition of their composites. The materials listed below were utilised in this project and are the same as those previously mentioned. Fibers made from hemp are: Hemp, often known as industrial hemp, is a strain of the Cannabis sativa plant that is primarily found in the northern hemisphere and cultivated particularly for the industrial usage of its derived products. Ten thousand years ago, it was one of the first plants spun into fibre, making it one of the fastest-growing plants. Paper, textiles, clothes, biodegradable plastics, paint,

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insulation, biodiesel, food, and animal feed may all be made from it.

robust and sturdy, able to tolerate temperatures of up to 23000 degrees Celsius In areas such as aerospace, aviation, defence and military, and vehicles, carbon fibres were a natural option because of their outstanding dimensional stability. Many people consider carbon to be high-tech material, and composite materials based on carbon are referred to as high-end materials.

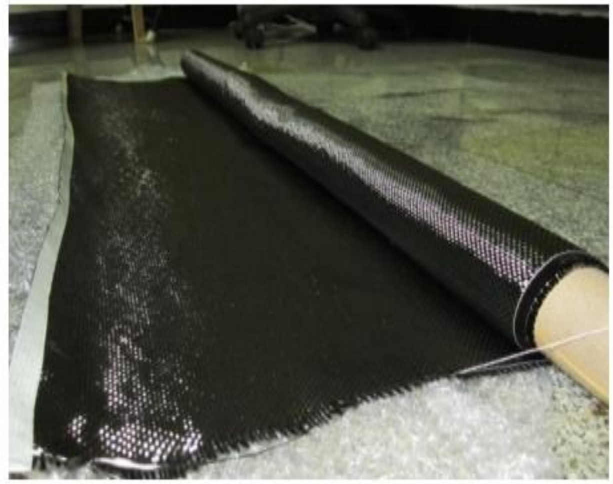

Fig 2.2: Carbon fibers.

Carbon Nanotubes: Carbon nanotubes (CNTs) resemble a sheet of graphite that has been wrapped up into a tube shape. One of the most common forms of carbon nanotubes are single-walled (SWCNTs) and multi-walled (MWCNTs) (MWCNTs).

Properties of CNTs :

As one of the strongest and stiffest materials, carbon nanotubes have a Young's modulus of more than one trillion pascals.

Stronger than steel by a factor of many hundred. Additionally, CNTs may withstand up to 15% strain before breaking.

elasticity is the elastic reaction to deformation Conductors having exceptional electrical characteristics

strong electrical conductivity (even 103 S/cm). Furthermore, CNTs can withstand temperatures of up to 2800 degrees Celsius.

Resins based on the g-backbone have curing qualities comparable to unsaturated polyester resins, such as vinyl ester (VE). Unsaturated sites—reactive groups exclusively found at the extremities of molecular

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chains—are what set VE resins apart from polyester.

Fig 2.4: Vinyl Ester resin.

B. Fabrication of the specimen.

The easiest approach of treating composites is to use the hand layup technique. This approach also has minimum infrastructure requirements. There are just a few basic processes involved in the production process. Woven, knitted, stitched or bonded textiles are impregnated by hand with resins. A revolving roller and a resin bath are used to force resin into the textiles, however nip roller type impregnators are more popular for doing this. During the curing process, laminates are exposed to normal air conditions.

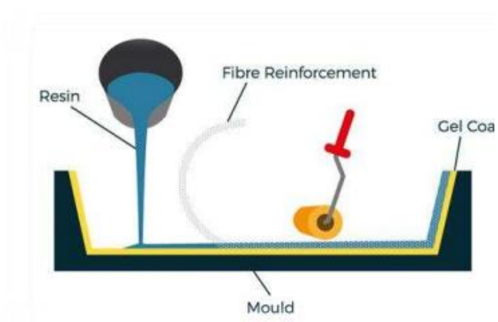


Fig 2.5: Hand layup technique.

C. Composition of the specimen

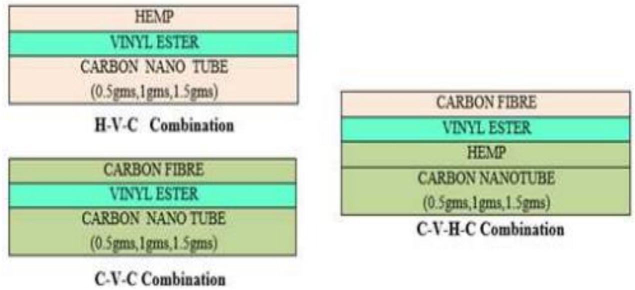
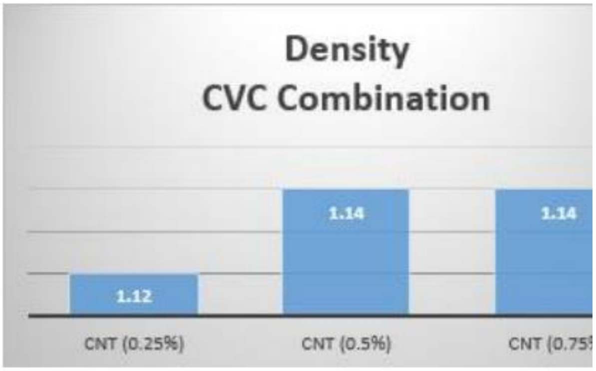


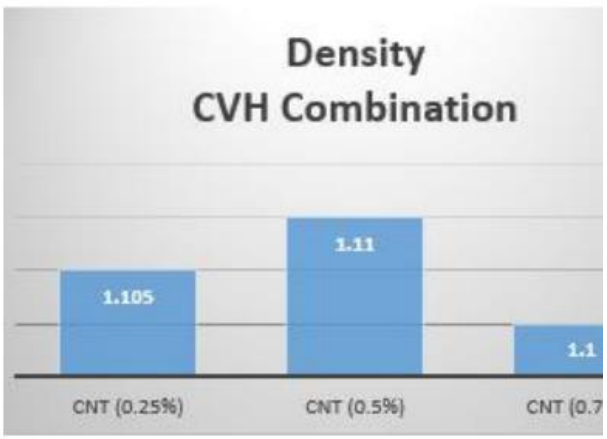
Fig 2.6 : Combination of fibers.

TESTING OF COMPOSITES

Density Test: The density test of hybrid nano composites are performed on laminates as per the ASTM standard D2734-35 while answers are presented in the table.

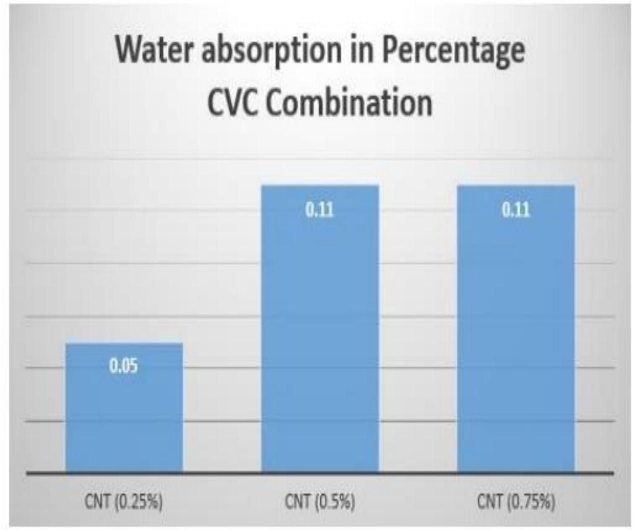
HVC combination		
Sl.No	SAMPLE (H-V-C)	Density
1	CNT (0.25%)	1.08
2	CNT (0.5%)	1.105
3	CNT (0.75%)	1.07
CVC combination		
Sl.No	SAMPLE (C-V-C)	Density
1	CNT (0.25%)	1.12
2	CNT (0.5%)	1.14
3	CNT (0.75%)	1.14
CVH combination		
Sl.No	SAMPLE (C-V-H)	Density
1	CNT (0.25%)	1.105
2	CNT (0.5%)	1.11





Water absorption Test

Moisture absorption testing is a gravimetric technique for monitoring changes in moisture content over time by measuring the total mass change of a specimen exposed to a specific environment, and water absorption testing is used to get the requisite quality of a composite specimen. ASTM D5229 is the standard for water absorption testing (100x100x4mm3). in which a sample exposed to a certain environment undergoes a total mass change measurement. For the water absorption test, ASTM D5229-compliant samples are employed (100x100x4mm3).



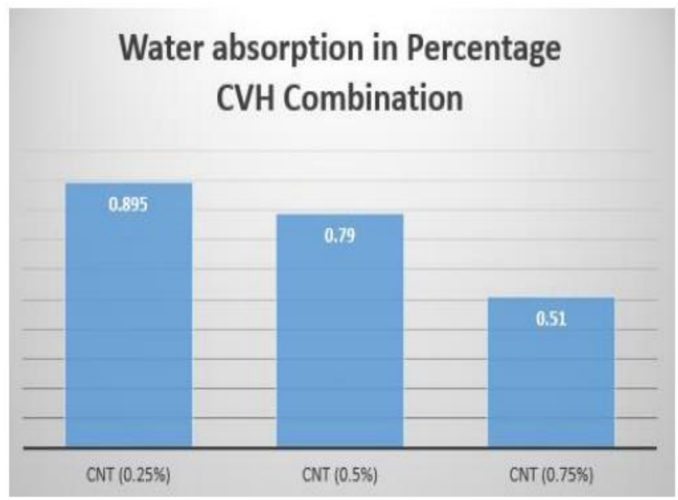


Fig 3.6: Water absorption test results of CVH combination.

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HVC combination		
Sl.No	SAMPLE (H-V-C)	Water absorption in Percentage
1	CNT (0.25%)	1.2
2	CNT (0.5%)	1.58
3	CNT (0.75%)	1.885
CVC combination		
Sl.No	SAMPLE (C-V-C)	Water absorption in Percentage
1	CNT (0.25%)	0.05
2	CNT (0.5%)	0.11
3	CNT (0.75%)	0.11
CVH combination		
Sl.No	SAMPLE (C-V-H)	Water absorption in Percentage
1	CNT (0.25%)	0.895
2	CNT (0.5%)	0.79
3	CNT (0.75%)	0.51

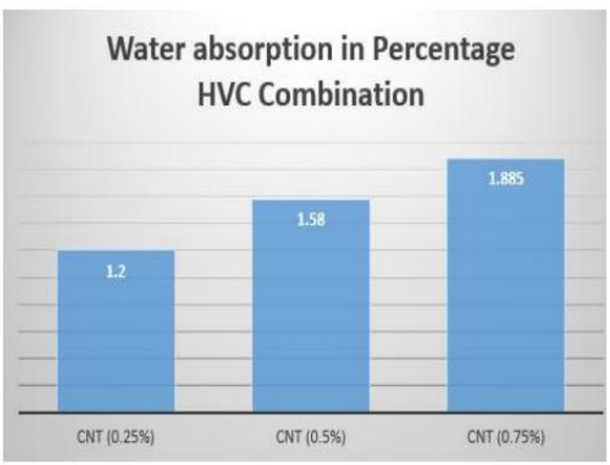


Fig 3.4: Water absorption test results of CVH combination.

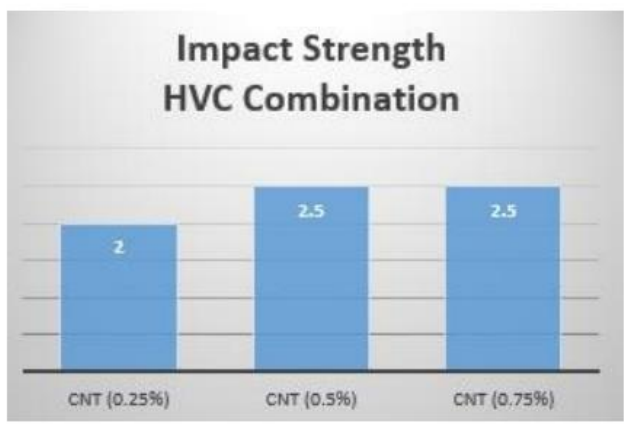
Impact Test

The density test of hybrid nano composites are performed on laminates as per the ASTM standard while answers are presented in the table.

HVC combination		
Sl.No	SAMPLE (H-V-C)	Impact Strength
1	CNT (0.25%)	2
2	CNT (0.5%)	2.5
3	CNT (0.75%)	2.5
CVC combination		
Sl.No	SAMPLE (C-V-C)	Impact Strength
1	CNT (0.25%)	2.5
2	CNT (0.5%)	2.5
3	CNT (0.75%)	2

CVH combination		
Sl.No	SAMPLE (C-V-H)	Impact Strength
1	CNT (0.25%)	2.5
2	CNT (0.5%)	2.5
3	CNT (0.75%)	2

Table: 3.3: Impact Test Results



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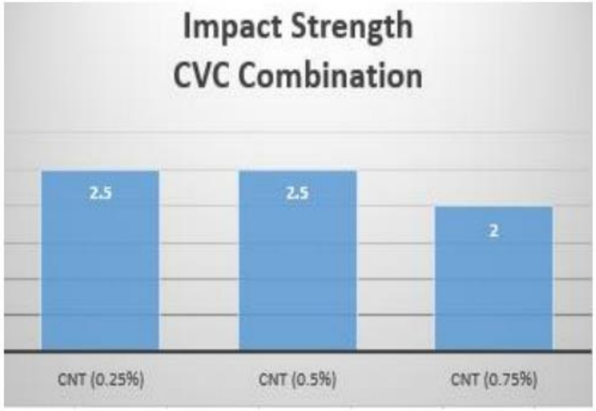

Fig 3.8: Impact test results of CVC combination

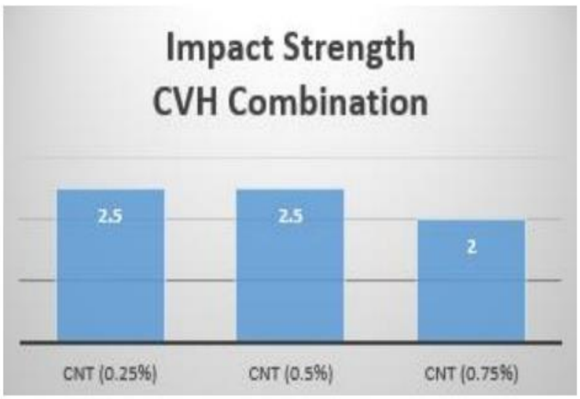

Fig 3.9: Impact test results of HVC combination

CONCLUSION

Hemp/Carbon fibre and Carbon nano tube reinforced composites are examined in this research. The mechanical characteristics of the

• Vinyl Ester fibres have nearly been increased by the introduction of carbon nanotubes. Carbon nanotubes have been shown to have a significant impact on the strength of Hemp/Carbon fibre composites. This work demonstrates the creation of a new product.

• Hemp/Carbon fibre reinforced hybrid composites based on Vinyl Ester are feasible. A basic hand lay-up method is used to

• produce a high-quality product CNT-reinforced hemp/carbon fibrefibres of varying amounts are seen. The overall weight-percentage increase in CNT

For example, compared to 0.5 and 0.75 percent CNT, 0.25 percent CNT had a greater impact strength than 0.25 percent CNT. Increased water carbon content is evident.decreasing absorption

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