iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: VIII Month of publication: August 2022

DOI: https://doi.org/10.22214/ijraset.2022.46269

A Study of Fabrication Method and Characterization of Jute fiber mat/Graphene/Multi wall carbon nanotube Reinforced Polymer Nanocomposite

Arun Kumar Sharma[1], Dr. Rakesh Bhandari[2], Dr. Shri Krishna Dhakad[3]

[1]*PhD Scholar, Mechanical Engineering Department, School of Engineering, Sangam University, Bhilwara Rajasthan, India*

[2]*Professor and Dean (Research & Advanced Studies), Mechanical Engineering Department, School of Engineering, Sangam University, Bhilwara Rajasthan, India*

[3]*Professor and Head, Mechanical Engineering Department, UIT-RGPV, Shivpuri, India*

Abstract: It is possible to lower the overall weight of automobiles in order to minimize waste of resources, enhance economic effectiveness, and optimize the performance of Vehicles. Currently, the utilization of composite materials rather than conventional materials is the primary significant way to reduce the weight of the automotive vehicles. Using polymer materials as a composite matrix in the industry may effectively decrease the quality of automobiles because strong moisture absorption characteristics, low impact and hardness properties than metal materials. It is well recognized that graphene is one of the strongest known materials, with exceptional toughness and electrical conductivity, and MWCNT also have exceptional mechanical properties and so in the polymer composite's mechanical and electrical characteristics may be improved significantly by dispersing graphene and MWCNT in polymer matrix. In the realm of materials, graphene/MWCNT-polymer composites are thus considered an excellent substitute of standard metal components in some applications. Current needs necessitate the use of hybrid materials of all varieties. The composites used in this research was created by hand layup process using LY556 epoxy resin and HY951 hardener, and the article examines the results of hybridization. Tests such as tensile, flexural, impact, and hardness indicate the attributes of all fabricated samples. The results of the test demonstrate that the (Jute Fibre Mat +Epoxy) composites with multi wall carbon nanotube MWCNT/Graphene in (1:5) ratio in sample 5 have considerably superior qualities than the other composites

Keywords: Polymer composites; Multiwall carbon nanotube; Graphene; Mechanical properties, Nano composite

I. INTRODUCTION

Automobile's weight reduction required to achieve minimized fuel consumption for the reduction in environmental pollution produced by emissions, which is a critical method to strengthen the competitiveness of automobiles [1]. It has been found that composite materials have the potential to greatly reduce the weight and cost of an automobile vehicles instead of metals [2].

II. HYBRID COMPOSITES

It's the matrix that holds the reinforcement in place and influences the desired qualities, but the fibers themselves are what give these composites their strength and stiffness [3]. Two or more reinforcing elements are combined to create a hybrid composite that minimizes the negative aspects of each other [4]. The goal of hybridization is to create a new material that retains the advantages of its elements while removing their drawbacks [5]. The usage of hybrid composites in a variety of products, including packaging and interior car elements has grown in recent years [6].

III. POLYMER MATRIX COMPOSITES

Reinforcement and matrix are the two main components of a composite. Metals, ceramics and polymers may be used as the matrix in the composite. Thermoplastic and thermosetting resins have been utilized widely as the matrix in polymer composites [7]. The majority of polymers that are economically significant have advanced uses. The market for polymer composites is exploding [8].

In the case of polymer composites, the polymer functions as a matrix. Automotive polymer composites are the subject of the latest research. Polymers have been used in high-tech applications for a long time now [9]. These are materials that may be used for a wide range of tasks due to their adaptability and ease of molding. However, a single polymer will not be able to match the needs of future applications. As a result, the world's attention was drawn to polymer composites [10].

To increase the material's performance, a variety of continuous and noncontinuous reinforcements and fillers are mixed with polymers. Their long-term performance and durability as well as their trustworthiness are of special importance, particularly in structural applications [11]. A lack of knowledge of polymer materials has hindered their use from the beginning of their existence, even in the earliest days of their existence [12].

IV. NATURAL FIBRE COMPOSITES

Natural fiber reinforced polymer composites have recently increased significantly in popularity because of their availability and low cost. Reinforced natural fibers in a polymer matrix may be able to develop lightweight and non-hazardous products [13]. When it comes to the production of powerful and cost-effective composites, materials like jute with good mechanical qualities are an ideal choice. Natural fibers, despite their many benefits, have a number of drawbacks, including high resin utilization [14].

A lot of attention has been paid to the possibilities and advantages of natural fiber as a reinforcing material during the last several decades. This is because natural fibers are light, inexpensive, and good for the environment [15]. There are now thermoplastic and thermoset composites made from natural fibers for door panels, seed bags, headliners, dashboards and other interior sections of automobiles [16]. Nowadays, composites made of fiber-reinforced polymer are regarded as a key component of engineering design and development. They have exceptional mechanical properties, unusual design freedom, and manufacturing simplicity [16]. A wide range of applications, including automobiles, spacecraft, offshore structures, containers, and sports goods are now frequently made from fiber composites. Composites may be made using a broad range of fibers [17].

Since fiber-reinforced composites have better mechanical qualities than metals, they are increasingly being employed in a broad range of industries [18]. Natural or synthetic fibers may be employed as reinforcement in composites, but natural fiber's abundant availability and inexpensive cost make it an excellent choice for usage as reinforcement [19]. Natural fiber reinforced polymer composites have risen to prominence in polymer matrix composites, in particular because of the expanding worldwide environmental concerns and ecological threats they pose. Because of its high cellulose content, jute fiber is the most promising reinforcing material. It is readily accessible in fabric and fiber form [20].

V. MATERIALS AND METHODS

Epoxy resins, a class of thermosetting resins, are used widely in a variety of sectors, including aircraft, automobiles, and shipping. The strong affinity of epoxy resins for natural fibers makes these resins helpful in the fabrication of composite materials reinforced with these fibres[21]. There are a variety of industrial uses for epoxy such as fiber reinforcement and adhesive applications because of its versatility and diversity. Only a few limitations prevent it from being used in a wide range of high-performance industries, such as limited impact resistance [22]. Epoxy's drawbacks may be mitigated by incorporating and modifying it before industrial use. These resins are now widely employed in natural fiber reinforced composites and a wide range of industrial goods due to their excellent mechanical, thermal, and electrical qualities [23].A typical two-dimensional nanomaterial, graphene has high strength, high toughness, high conductivity, and many other excellent properties. At the same time, graphene is lighter than most metals and has better mechanical and electrical properties, making it widely used in industrial research [24]. A multi-wall carbon nanotube (MWCNT) is made up of two or more nested single-wall carbon nanotubes. Adding Graphene or MWCNT to polymer materials as fillers has been found to increase the original matrix material's toughness and conductivity by enhancing its properties [25].

Jute fiber/MWCNT and graphene as reinforcement and epoxy resin as matrix were used to create the test specimens. Araldite HY 556 and hardener HY 951 were combined in a volume ratio of 15:1 to manufacture of the epoxy resin matrix. Foam tape was used to make a 300mmx300mm mold on a marble base. To keep the samples' surfaces from adhering to the marble, employed a mold-releasing wax. MWCNT and graphene in deferent proportions were mixed in acetone according to sample requirement and then mixed by mechanical stirrer. To remove acetone from the mixture it was heated on a bath sonicator and magnetic stirrer till all acetone was removed. Afterward, this liquid was completely mixed with a hardener (curing agent) and poured on top of the mat that has previously been set in the mold in the appropriate position. Using a brush and an epoxy material was successively applied on top of one another jute fiber mat layers. The brush is used to apply the epoxy. The laminates were rolled using a hand roller to eliminate the air content and extra epoxy, a roller is gently pushed over the mat-epoxy layer before the second layer of the mat is put on top. It is continued for every layer of epoxy and mat until the 6 number of layers are layered.

For 24 hours, laminates were allowed to cure at room temperature. Finally, the specimens for testing as per ASTM were cut to the appropriate dimensions. The experimental findings were evaluated by preparing five specimens of each kind of reinforcing volume. Sample 1-5 consists (MWcnt +Graphne) in 0.30 weight % in different ratio(1:5,1:2,1:1,2:1 and 1:5) and 30% jute mat fiber for samples 1-6 where the remaining weight% was for Epoxy and sample 7 consist 100% epoxy resin.

VI. RESULTS AND DISCUSSION

After cutting the composite sample in appropriate dimensions according to the ASTM standards, tests were carried out

A. *Tensile Test*

For evaluation of tensile properties, a universal testing machine (UTM) is utilized. Figure 1 and Fig 2 show the results of tensile testing on several composite specimens made from various fiber combinations. Five samples of each composite type are examined and the average is given. The load is applied to the specimen, and the results are recorded. In order to determine the ultimate tensile strength, the specimens are subjected to the maximum load possible.

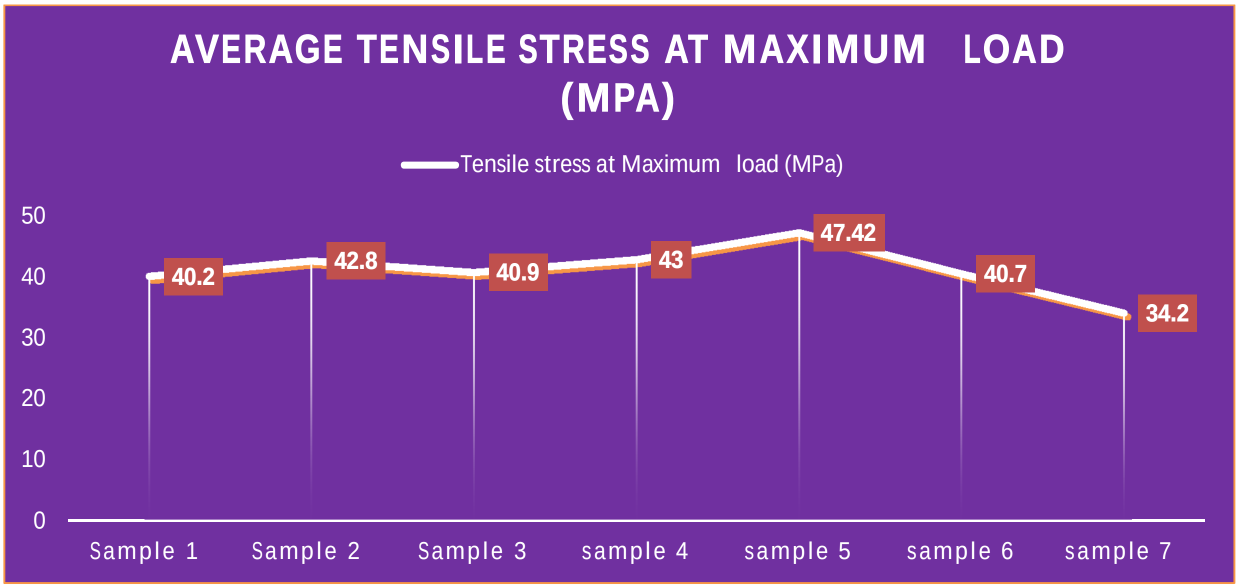

Fig 1: Average Tensile Stress at Maximum load (MPa)

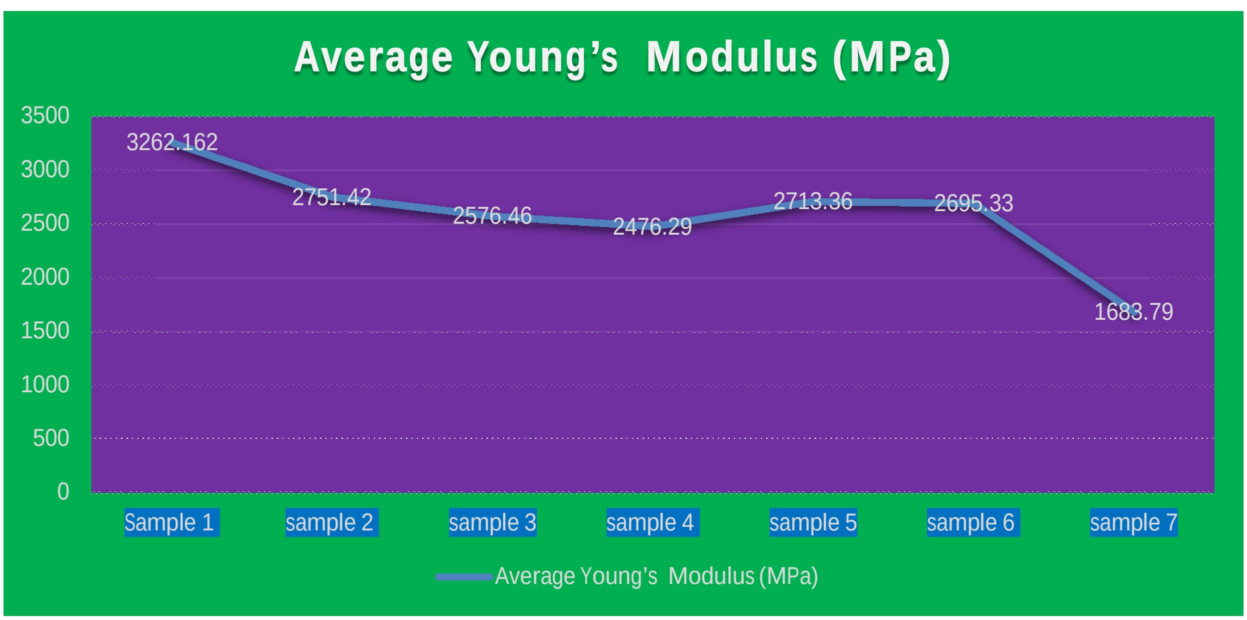

Fig 2: Young's Modulus (MPa)

Sample 5 shows the highest Average tensile stress at max load (MPa) and sample 1 show Young's Modulus (MPa) compared to all samples.

B. Flexural Test

Flexural tests are performed by cutting the composite plate into samples with proper dimensions, as per ASTM standard.

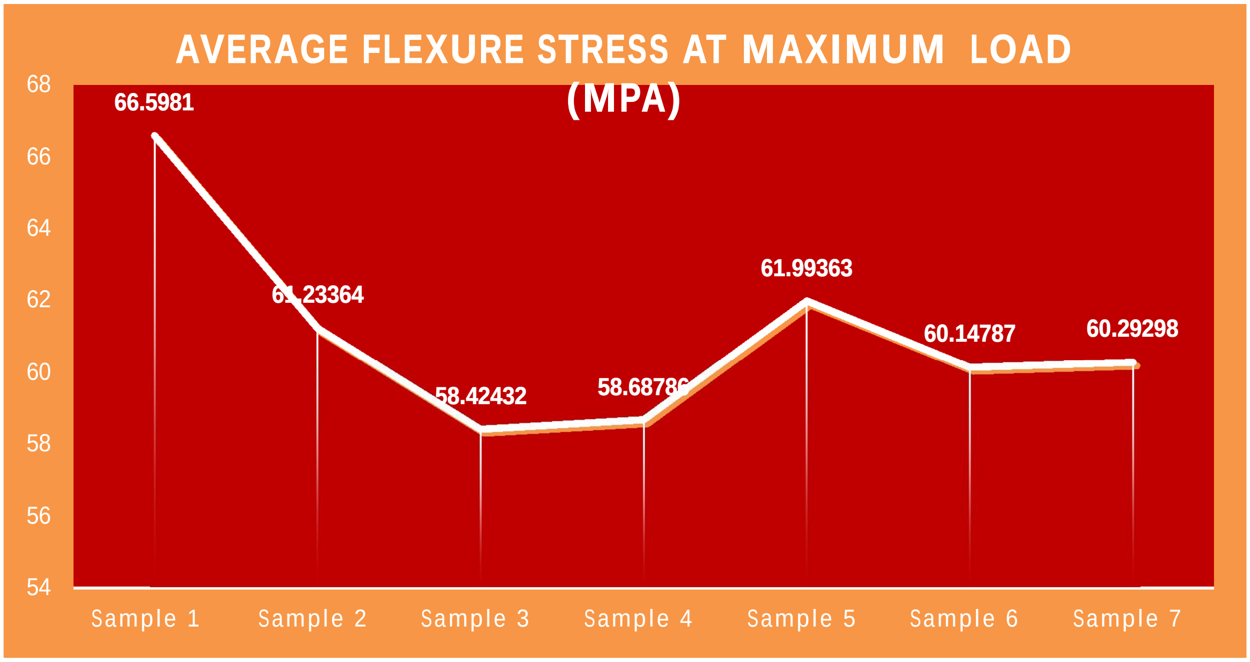

Fig 3: Flexural Stress at Maximum Load (MPa)

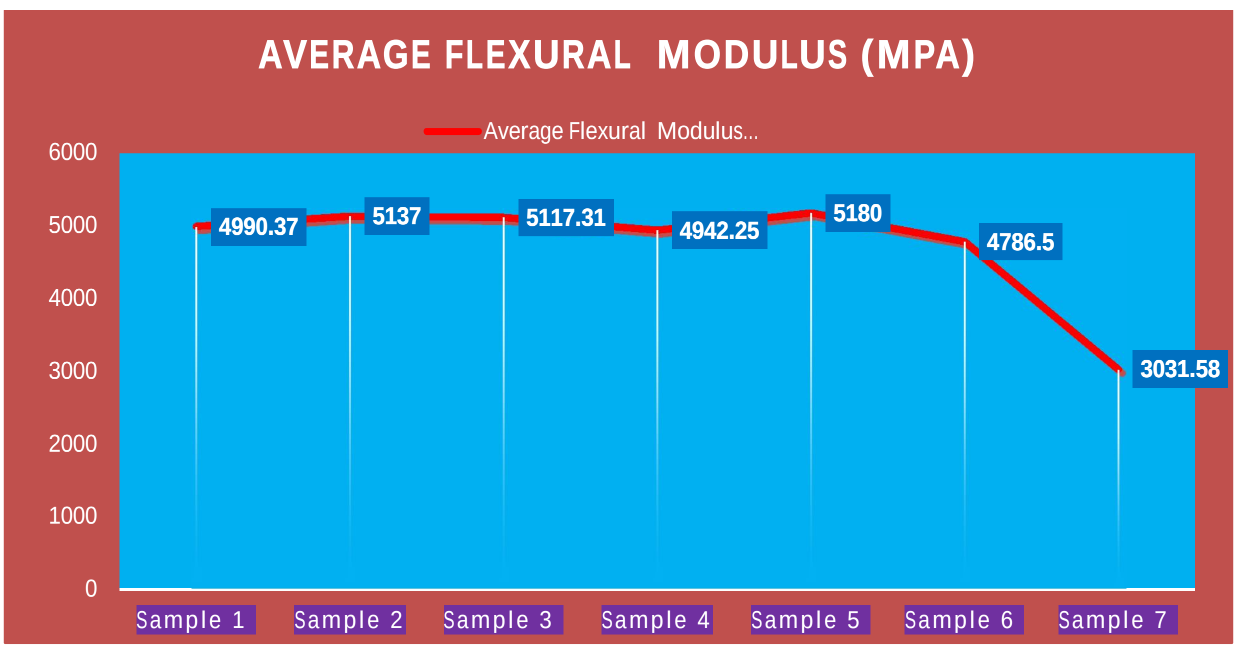

Fig 4: Average Flexural Modulus (MPa)

A universal testing machine (UTM) was used for testing. Figure 3 and Fig 4 show the results of flexural testing on several composite specimens made. In accordance with ASTM a three-point flexural test is performed.

As shown in figures 3 and 4, tests on composite specimens built from a variety of fibre combinations showed varying outcomes.

Five samples of each composite type are examined. The average of five different composite samples is calculated. Sample 1 show the highest Average Flexural stress at max load (MPa) and sample 5 shows highest value of flexural Modulus (MPa) compared to all samples.

C. Hardness Test

Average Hardness value calculated by shore hardness tester and sample 5 exhibit highest value compared to all fabricated samples and results are shown in fig 5.

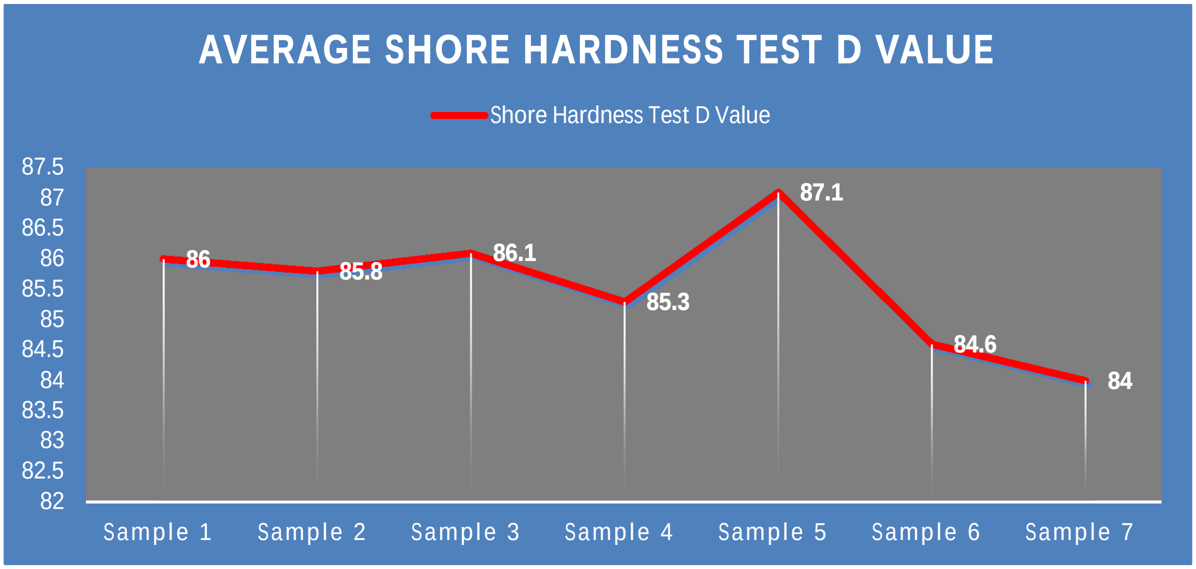

Fig 5: Average Shore Hardness Test D value

D. Impact Test

Izod impact tester used for impact testing and results for all fabricated samples are shown in fig 6 and fig 7. It is shown that sample 5 has highest impact properties compared to all samples.

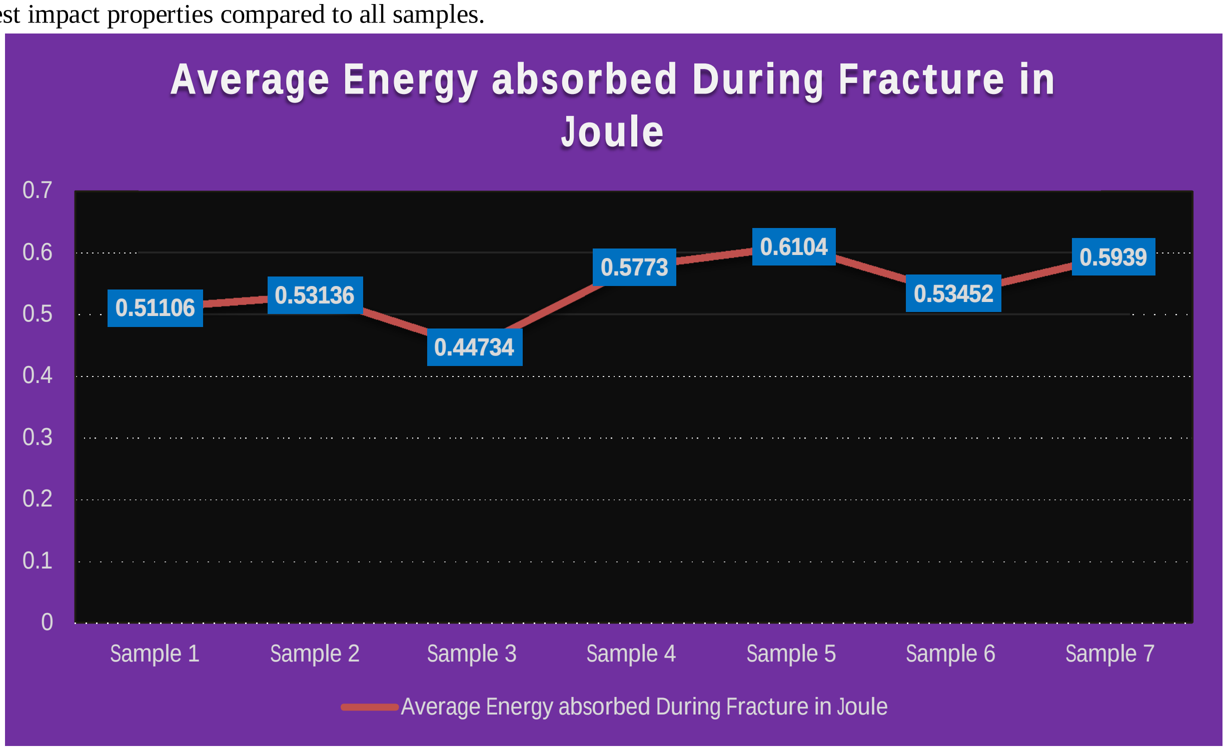

Fig 6: Average Brake Energy in Joule

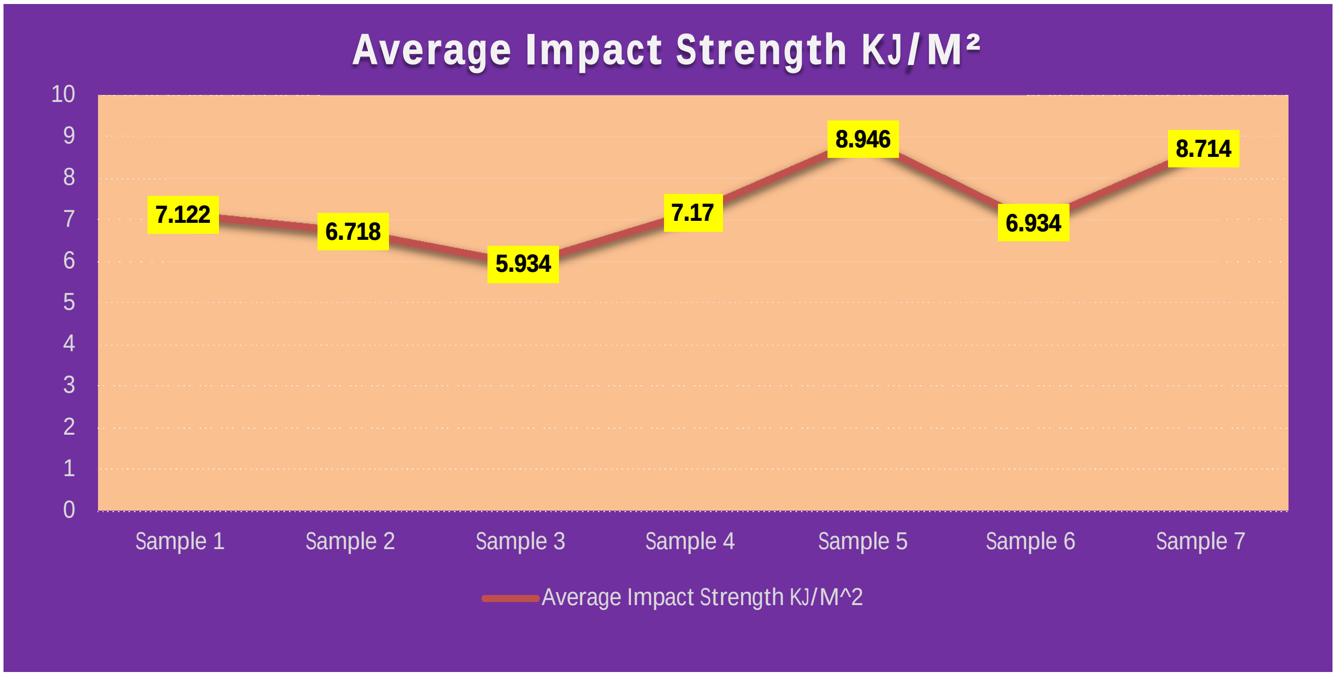

Fig 7: Average Impact Strength in KJ/M²

VII. CONCLUSIONS

In a laminated composite, the volume % of the reinforcement has a significant impact on its mechanical characteristics. A laminated composite's strength and mechanical characteristics may be considerably depended on the volume proportion of MWCNT and Graphene in the laminated composite. The samples were fabricated using by hand lay-up in accordance with ASTM specifications. In order to determine the tensile and flexural properties of composite laminates a computerized UTM was used and on it many tests were carried out. For composites with desired strength and mechanical qualities, the proportion of reinforcement material's volume may be critical.

REFERENCES

[1] Arun kumar Sharma, Rakesh Bhandari, Amit Aherwar, Ruta Rimašauskienė (link), Matrix "materials used in composites: A comprehensive study",Materials Today: Proceedings (2020) 21(3) 1559-1562
[2] Vigneshwaran, S., R. Sundarakannan, K. M. John, R. Deepak Joel Johnson, K. Arun Prasath, S. Ajith, V. Arumugaprabu, and M. Uthayakumar. "Recent advancement in the natural fiber polymer composites: A comprehensive review." Journal of Cleaner Production 277 (2020): 124109.
[3] C Pinca-Bretotean, A L Crăciun, C Preda and Arun kumar Sharma "Physico-mechanical and tribological characteristics of composite materials used for brake pads", Journal of Physics: Conference Series 1781 (2021) 012032
[4] Aisyah, H. A., M. T. Paridah, S. M. Sapuan, R. A. Ilyas, A. Khalina, N. M. Nurazzi, S. H. Lee, and C. H. Lee. "A comprehensive review on advanced sustainable woven natural fibre polymer composites." Polymers 13, no. 3 (2021): 471.
[5] Nurazzi, N. M., M. R. M. Asyraf, S. Fatimah Athiyah, S. S. Shazleen, S. Ayu Rafiqah, M. M. Harussani, S. H. Kamarudin et al. "A review on mechanical performance of hybrid natural fiber polymer composites for structural applications." Polymers 13, no. 13 (2021): 2170.
[6] Arun Kumar Sharma, Rakesh Bhandari, Chaitanya Sharma, Shri Krishna Dhakad, Camelia Pinca-Bretotean,Polymer matrix composites: A state of art review,Materials Today: Proceedings,Volume 57, Part 5,2022,Pages 2330-2333
[7] Alsubari, S., Zuhri, M.Y.M., Sapuan, S.M., Ishak, M.R., Ilyas, R.A. and Asyraf, M.R.M., 2021. Potential of natural fiber reinforced polymer composites in sandwich structures: A review on its mechanical properties. Polymers, 13(3), p.423.
[8] C Pinca Bretotean, Arun Kumar Sharma , A Josan Investigation of functional characteristics of composites used for brake pads, Journal of Physics: Conference Series 2212 ((2022)), 012024
[9] Senthilkumar, K., Naheed Saba, N. Rajini, M. Chandrasekar, Mohammad Jawaid, Suchart Siengchin, and Othman Y. Alotman. "Mechanical properties evaluation of sisal fibre reinforced polymer composites: A review." Construction and Building Materials 174 (2018): 713-729.
[10] Kumar, Amit, Kamal Sharma, and Amit Rai Dixit. "A review on the mechanical properties of polymer composites reinforced by carbon nanotubes and graphene." Carbon letters 31, no. 2 (2021): 149-165.
[11] Zakaria, Muhammad Razlan, Hazizan Md Akil, Muhammad Helmi Abdul Kudus, Faheem Ullah, Fatima Javed, and Norlin Nosbi. "Hybrid carbon fiber-carbon nanotubes reinforced polymer composites: A review." Composites Part B: Engineering 176 (2019): 107313.
[12] Shahabaz, S. M., Sathyashankara Sharma, Nagaraja Shetty, S. Divakara Shetty, and M. C. Gowrishankar. "Influence of temperature on mechanical properties and machining of fibre reinforced polymer composites: a review." Engineered Science 16 (2021): 26-46.
[13] Chen, Junjie, Longfei Yan, Wenya Song, and Deguang Xu. "Interfacial characteristics of carbon nanotube-polymer composites: A review." Composites Part A:

Applied Science and Manufacturing 114 (2018): 149-169.
[14] Praveenkumara, J., P. Madhu, T. G. Yashas Gowda, M. R. Sanjay, and Suchart Siengchin. "A comprehensive review on the effect of synthetic filler materials on fiber-reinforced hybrid polymer composites." The Journal of the Textile Institute 113, no. 7 (2022): 1231-1239.
[15] Jariwala, Hitesh, and Piyush Jain. "A review on mechanical behavior of natural fiber reinforced polymer composites and its applications." Journal of Reinforced Plastics and Composites 38, no. 10 (2019): 441-453.
[16] Khan, Mohammad ZR, Sunil K. Srivastava, and M. K. Gupta. "Tensile and flexural properties of natural fiber reinforced polymer composites: A review." Journal of Reinforced Plastics and Composites 37, no. 24 (2018): 1435-1455.
[17] Vijay Kumar, Vishnu, G. Balaganesan, Jeremy Kong Yoong Lee, Rasoul Esmaeely Neisiany, S. Surendran, and Seeram Ramakrishna. "A review of recent advances in nanoengineered polymer composites." Polymers 11, no. 4 (2019): 644.
[18] Jagadeesh, Praveenkumara, Yashas Gowda Thyavihalli Girijappa, Madhu Puttegowda, Sanjay Mavinkere Rangappa, and Suchart Siengchin. "Effect of natural filler materials on fiber reinforced hybrid polymer composites: An Overview." Journal of Natural Fibers (2020): 1-16.
[19] Kumar, Rajiv, Mir Irfan Ul Haq, Ankush Raina, and Ankush Anand. "Industrial applications of natural fibre-reinforced polymer composites–challenges and opportunities." International Journal of Sustainable Engineering 12, no. 3 (2019): 212-220.
[20] Li, Yunlong, Quan Wang, and Shijie Wang. "A review on enhancement of mechanical and tribological properties of polymer composites reinforced by carbon nanotubes and graphene sheet: Molecular dynamics simulations." Composites Part B: Engineering 160 (2019): 348-361.
[21] Pham, Ha Q., and Maurice J. Marks. "Epoxy resins." Ullmann's Encyclopedia of Industrial Chemistry (2000).\
[22] Jin, Fan-Long, Xiang Li, and Soo-Jin Park. "Synthesis and application of epoxy resins: A review." Journal of Industrial and Engineering Chemistry 29 (2015): 1-11.
[23] May, Clayton, ed. Epoxy resins: chemistry and technology. Routledge, 2018.
[24] Bouhfid, Rachid, and Mohammad Jawaid, eds. Graphene and Nanoparticles Hybrid Nanocomposites: From Preparation to Applications. Singapore: Springer, 2021.
[25] Gangu, Kranthi Kumar, Suresh Maddila, Saratchandra Babu Mukkamala, and Sreekantha B. Jonnalagadda. "Characteristics of MOF, MWCNT and graphene containing materials for hydrogen storage: A review." Journal of energy chemistry 30 (2019): 132-144.
[26]