INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 05, May 2024, pp: 1986-1996

e-ISSN : 2583-1062

Impact Factor: 5.725

FABRICATION AND TESTING OF COMPOSITE MATERIAL USING SILKCOCOON'S THREADS

A. Bhargav[1], Ch. Raju[2], P. Pavan Kumar Reddy[3], Mattaparthi Sairahul[4], K. Jaison Sarkar[5], S. Vishnu Vardhan[6]

[1,2]Assistant Professor, Department of Mechanical Engineering, Ace Engineering College, India.

[3,4,5,6]Students, Department of Mechanical Engineering, Ace Engineering College, India.

DOI: https://www.doi.org/10.58257/IJPREMS34519

ABSTRACT

The fabrication of composite materials using silk cocoon threads represents a convergence of tradition and innovation, offering a wide range of applications across industries. This project provides a comprehensive and detailed examination of the fabrication process, covering each step from material selection and preparation to impregnation, curing, and testing. Beginning with an overview of the unique properties of silk cocoon threads, including their strength, lightweight nature, flexibility, and biocompatibility, it explores the various types of silk cocoons available, such as mulberry silk, wild silk, and tussah silk, and discusses their respective properties and suitability for specific applications. The project then deals with resin options for impregnating silk cocoon threads, considering factors such as curing mechanisms, processing considerations, and compatibility with silk fibers. Fiber reinforcement options, including carbon fibers, glass fibers, aramid fibers, and natural fibers, are also explored for enhancing the mechanical properties of composite materials. The preparation of silk cocoon threads, including impregnation and bonding withthe resin matrix. Testing and evaluation procedures, including tensile testing, elongation testing, hardness testing, microstructure testing, and impact testing, are thoroughly discussed to ensure the integrity, reliability, and performance of the composite materials. Safety and environmental considerations are followed throughout the fabrication process, with a focus on minimizing risks, reducing environmental impact, and promoting sustainable practices.

1. INTRODUCTION

A composite material is a combination of two materials with different physical and chemical properties. When they are combined, they create a material which is specialized to do a certain job,for instance to become stronger, lighter or resistant to electricity. They can also improve strength and stiffness.

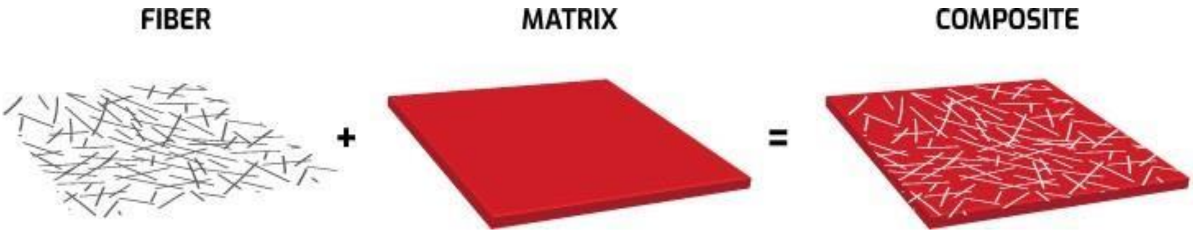


Fig: 1.1 Composite Material

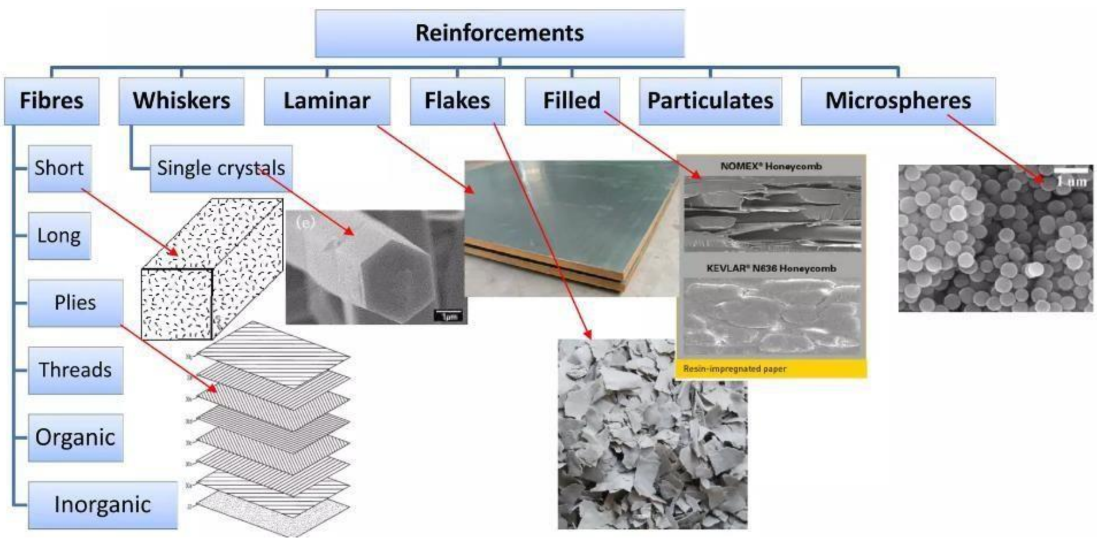


Fig: 1.2 Types of Composite Materials

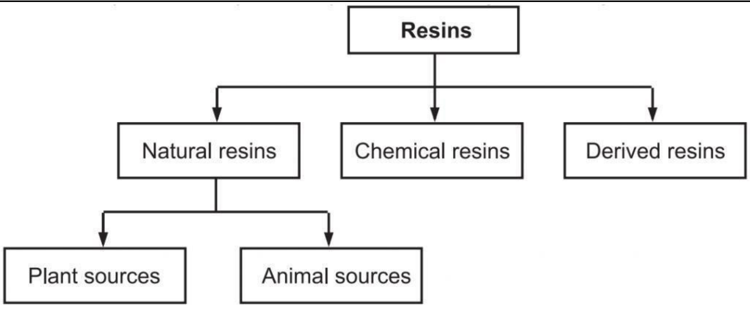


Fig: 1.3 Types of Resins

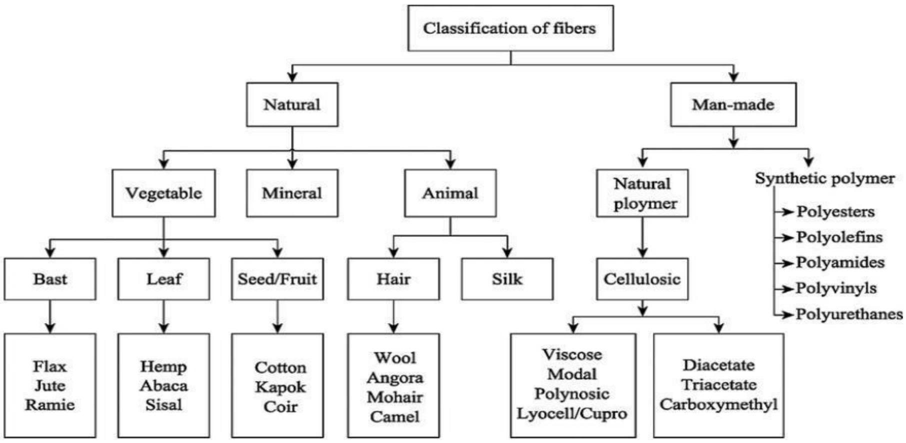


Fig: 1.4 Types of Fibers

COMPOSITE MATERIALS USING NATURAL MATERIALS:

Natural composite materials are formed by combining different elements from the natural world tocreate substances with enhanced properties. These materials have been utilized by humans for various purposes throughout history

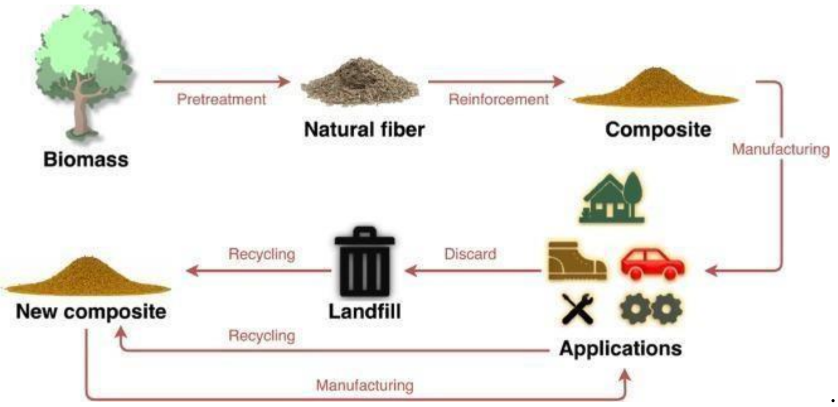


Fig: 1.5 Composite using Natural Materials

Fig: 1.7 Natural Fiber.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 05, May 2024, pp: 1986-1996

e-ISSN : 2583-1062

Impact Factor: 5.725

Stifling & Sorting:

T stop the pupa inside the cocoons from hatching and breaking the silk cocoon, the pupa will have to be killed. This process is called stifling and is usually done using hot air or steam. Stifling also dries out the cocoon so that it can be preserved longer. The cocoons can then be sorted based on quality and characteristics such as the length, shape, colour, and luster of the silk fiber.

Fig: 1.15 Stifling

Boiling:

After stifling, the cocoons will be exposed to heat once again to prepare them for unreeling. The cocoons are put in boiling water to soften them. Cooking them makes it easier to find the end of thesingle silk fiber that makes up the cocoons. It also makes it simpler to unwind them.

Fig: 1.16 Boiling

Fig: 1.17 Reeling

Fig: 1.18 Twisting

Weaving:

Silk yarn is transformed into a silk fabric by weaving the threads. There are many ways to weave silk. One of the most popular methods for weaving silk is called charmeuse, also known as satin. Thecharmeuse weave is a tight weave that results in a smooth and shiny silk fabric. Silk charmeuse fabrics have a glossy surface and a dull back. This look is achieved by floating the lengthwise threadover three or more transverse threads.

2. LITERATURE REVIEW

2.1 Daiqi Liab, Bin Tang a b, Xi Luc, Wu Chena, Xiongwei Donga, Jinfeng Wang b: Hierarchically carbonized silk/ceramic composites for electro-thermal conversion: This research simplified the process of making carbon fiber/ceramic composites by combining the steps of carbonizing fibers and ceramizing ceramic precursors into one. They used silk fabric and silkwormcocoons as raw materials and heated them together to make the composites. This method created both carbonization and mullite formation simultaneously in a nitrogen environment. The resulting composites made from three-layer silk fabric heated to over 100°C in 30 seconds and stabilized at 239°C after 540 seconds when a 10V voltage was applied. These composites also had stable heatingcycles, even heat distribution, and electromagnetic shielding properties, suggesting potential for usein various applications, especially in electro-thermal conversion.

2.2 Sanyukta Gupta: Preparation and characterization of waste Silk fiber reinforced polymercomposites: Synthetic fiber-reinforced polymer composites offer high stiffness and strength-to- weight ratio but face declining use due to cost and environmental concerns. Natural fibers, includingsilk, are gaining attention for being biodegradable, low-cost, and strong. Waste silk fibers from silkmanufacturing, known locally as "Ghincha," are being explored for value-added applications. This study investigates the preparation and characterization of epoxy composites with varying amounts of waste silk fibers. Experiments were conducted under different environmental conditions, and shearstrength was evaluated. The erosion wear behavior of silk fiber composites and hybrids with jute andsynthetic fiber glass was also studied. Results suggest potential applications in partition boards, falseceilings, doors, and window panels due to their environmental resilience and improved erosion resistance through hybridization.

2.3 Fritz Vollrath, Fujia Chen and David Porter: silks and their composites: Silk polymers have evolved as key structural components in a wide range of animal constructions. Examination ofboth silk fibres and silk structures, be they gossamer webs or paper-like cocoons, reveals intriguinginsights into Nature's way of making materials and composites of considerable potential for novel insights with practical implications.

2.4 Feng Wang, Chengchen Guo, Chunmei Li, Ping Zhao, Qingyou Xia and David L. Kaplan:Protein composites from silkworm cocoons as versatile biomaterials: The research is exploring innovative ways to utilize both fibroin and sericin proteins from silk in biomedical applications. Bycreating fibroin-sericin protein composites directly from whole cocoons, you're leveraging the beneficial properties of both components while simplifying the fabrication process.

This approach could indeed open up new possibilities for materials in biomedical contexts, offering advantages in terms of processing and resulting properties.

2.5 S. M. Darshan, B.Suresha, G.S.Divya: Waste Silk Fiber Reinforced Polymer Matrix Composites: A Review: Researchers, engineers, and scientists are increasingly interested in using natural fibers as an alternative to synthetic fibers in fiber reinforced polymer composites (FRPCs). Natural fibers, like silk, are appealing because they are inexpensive, have good mechanical properties, are environmentally friendly, and biodegradable. Silk, in particular, is highly valued andhas various uses, including in textiles and as reinforcement in composite parts for automotive applications. This paper examines the use of waste silk fibers in FRPCs, discussing processing methods, mechanical properties, and challenges in characterization. The findings can contribute to advancements in the automotive sector.

2.6 Sanyukta Gupta: Preparation and characterization of waste Silk fiber reinforced polymercomposites: Synthetic fiber-reinforced polymer composites offer high stiffness and strength-to- weight ratio but face declining use due to cost and environmental concerns. Natural fibers, includingsilk, are gaining attention for being biodegradable, low-cost, and strong. Waste silk fibers from silkmanufacturing, known locally as "Ghincha," are being explored for value-added applications. This study investigates the preparation and characterization of epoxy composites with varying amounts of waste silk fibers. Experiments were conducted under different environmental conditions, and shearstrength was evaluated. The erosion wear behavior of silk fiber composites and hybrids with jute andsynthetic fiber glass was also studied. Results suggest potential applications in partition boards, falseceilings, doors, and window panels due to their environmental resilience and improved erosion resistance through hybridization.

2.7 Jiayun Hu, Yan Zhang, Chunling Liang, Ping Wang, Dongmei Hu: The preparation and chara-cteristics of high puncture resistant composites inspired by natural silk cocoon: Bombyx moricocoon, a natural nonwoven material has excellent puncture resistance and unique structure. Based

on the structure of cocoon, this paper designed a biomimicry composite, aiming to improve the staticpuncture resistance through polyurethane impregnated treatment. In this article, four different typesof polyurethane (TPU 85 A, TPU 90 A, PEUR 855 A, PEUR 991 A) are selected and fiveconcentration gradients (5, 7, 9, 11, 13 wt%) are set. The tensile and static puncture resistance of theimpregnated composites and damaged morphology after puncture are systematically studied. The results show that the static puncture resistance of nonwovens impregnated by polyurethane is improved obviously. This study provides a new way to design better static puncture resistant materials.

3. MATERIALS

PREPARATION OF MATRIX MATERIAL

The preparation of the matrix material is a critical step in the fabrication of composite materials using silk cocoon threads.

Fig: 3.1 Mixing Resin

Fabrication process

The fabrication process of composite materials using silk cocoon threads involves a series of stepsaimed at combining the reinforcement fibers (silk cocoon threads) with a matrix material (resin) to produce a composite structure with enhanced mechanical properties and performance.

4. MOLD PREPARATION

Mold preparation is a crucial step in the fabrication process of composite materials using silk cocoon threads. A well-prepared mold ensures the accurate shaping and curing of the composite structure, ultimately determining the quality and integrity of the final product.

The mold serves as the negative form into which the composite materials are placed and shaped during the fabrication process. Proper mold preparation is essential to achieve the desired shape, surface finish, and dimensional accuracy of the composite part. The type of mold used (e.g., rigid,flexible) and the mold surface treatment can significantly influence the fabrication process and theproperties of the final composite.

Fig: 4.1 Mold preparation

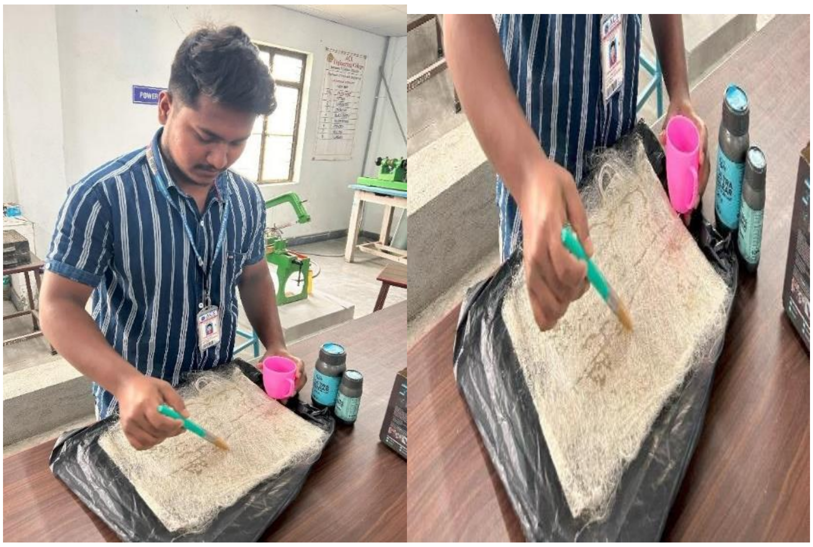


Fig: 4.2 Applying resin to cocoon matrix

Fig: 4.3 Before Curing

Vol. 04, Issue 05, May 2024, pp: 1986-1996
e-ISSN : 2583-1062
Impact Factor: 5.725

5. TESTING AND EVALUVATION

Testing and evaluation are essential aspects of the fabrication process for composite materials using silk cocoon threads. They ensure that the final composite products meet specified standards for mechanical performance, dimensional accuracy, and overall quality.

TENSILE TEST

A tensile test, also known as tension test, is a common mechanical test used to evaluate the mechanical properties of materials, including composite materials fabricated using silk cocoon threads. Here's an introduction to the tensile test:

Fig: 5.1 Universal Testing Machine

Purpose:

The purpose of a tensile test is to determine how a material responds to axial stretching forces, allowing for the measurement of key mechanical properties such as tensile strength, elongation atbreak, modulus of elasticity, and yield strength.

Procedure:

Specimen Preparation:

Test specimens are prepared from the composite material, typically in the form of flat or cylindrical samples with standardized dimensions. Care is taken to ensure that the specimens are free from defects and manufactured according to relevant standards.

Mounting the Specimen:

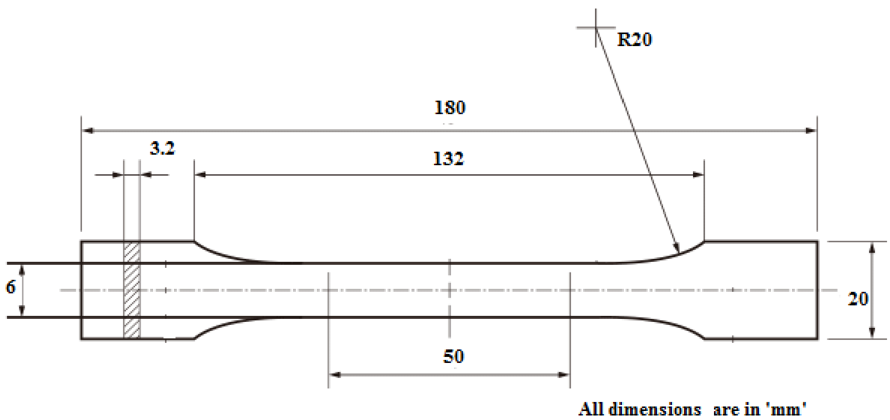


Fig: 5. 2 Specimen size

The specimen is securely mounted onto the grips of a tensile testing machine, which applies a controlled axial load to the specimen. The grips ensure proper alignment and distribution of the applied force.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
www.ijprems.com
editor@ijprems.com
Vol. 04, Issue 05, May 2024, pp: 1986-1996
e-ISSN : 2583-1062
Impact Factor: 5.725

Application of Load:

The tensile testing machine applies a gradually increasing tensile force to the specimen at a constant rate. The rate of loading is specified by relevant testing standards and can vary dependingon the material and desired test parameters.

Measurement of Load and Deformation:

Throughout the test, the tensile testing machine continuously measures the applied load and the corresponding deformation (strain) experienced by the specimen.

Fig: 5.3 Before Tensile Test

Analysis of Results:

The tensile test generates a stress-strain curve, which plots the relationship between applied stress(force per unit area) and strain (deformation) experienced by the specimen. Key parameters such as tensile strength, yield strength, modulus of elasticity, and elongation at break are determined from the stress-strain curve.

Failure Analysis:

Fig: 5.4 After Tensile Test

The test continues until the specimen fractures or breaks. The mode of failure, whether it's a suddenrupture or gradual necking, provides valuable insights into the material's behavior under tension and its structural integrity.

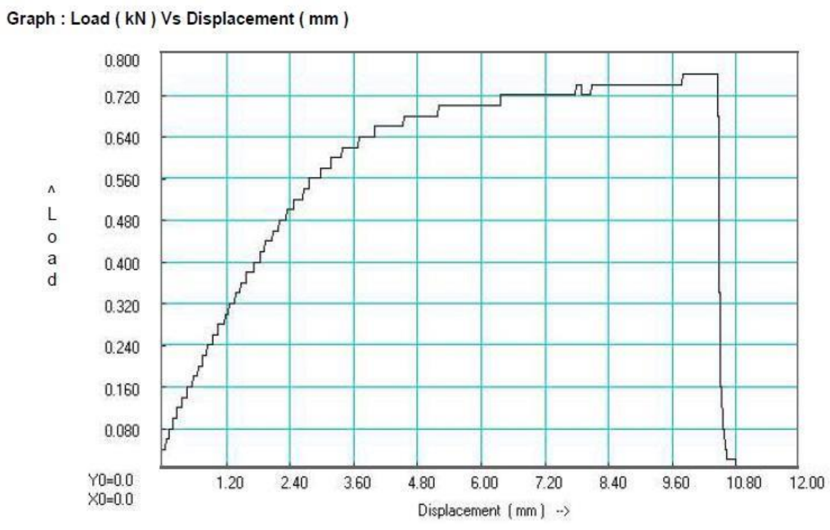


Fig: 5.5 Load vs Displacement graph

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
www.ijprems.com
editor@ijprems.com
Vol. 04, Issue 05, May 2024, pp: 1986-1996
e-ISSN : 2583-1062
Impact Factor: 5.725

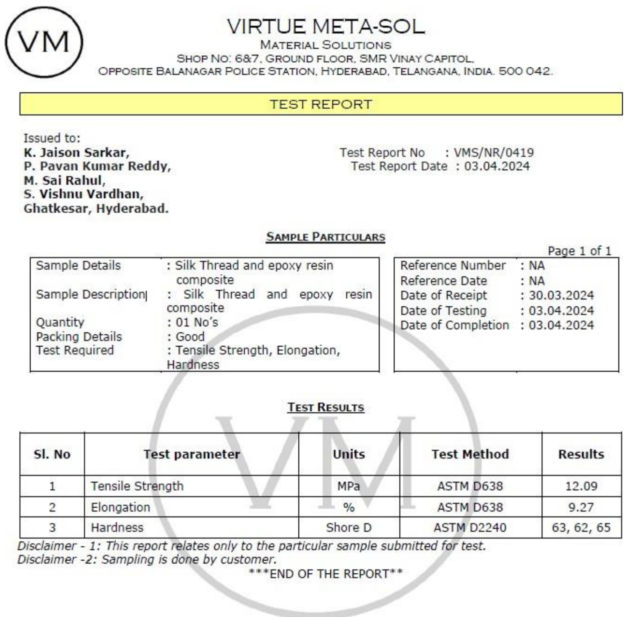
Significance:

- Tensile testing provides valuable data on the mechanical properties of composite materials,including their strength, stiffness, ductility, and toughness.
- The results of tensile tests help engineers and designers understand how materials behave under tension and inform material selection, structural design, and performance optimization.
- Tensile testing is widely used in quality control, material certification, research, and development across various industries, including aerospace, automotive, construction, andmanufacturing.

ELONGATION TEST

An elongation test, also known as an elongation at break test or simply elongation test, is a mechanical test used to measure the extent to which a material stretches or deforms before breakingunder tension.

Fig: 5.6 Elongation Testing equipment



VM

VIRTUE META-SOL
MATERIAL SOLUTIONS
SHOP NO: 6&7, GROUND FLOOR, SMR VINAY CAPITOL,
OPPOSITE BALANAGAR POLICE STATION, HYDERABAD, TELANGANA, INDIA. 500 042.

TEST REPORT

Issued to:
K. Jaison Sarkar,
P. Pavan Kumar Reddy,
M. Sai Rahul,
S. Vishnu Vardhan,
Ghatkesar, Hyderabad.

Test Report No : VMS/NR/0419
Test Report Date : 03.04.2024

SAMPLE PARTICULARS

Page 1 of 1

Sample Details	: Silk Thread and epoxy resin composite
Sample Description	: Silk Thread and epoxy resin composite
Quantity	: 01 No's
Packing Details	: Good
Test Required	: Tensile Strength, Elongation, Hardness

Reference Number	: NA
Reference Date	: NA
Date of Receipt	: 30.03.2024
Date of Testing	: 03.04.2024
Date of Completion	: 03.04.2024

TEST RESULTS

Sl. No	Test parameter	Units	Test Method	Results
1	Tensile Strength	MPa	ASTM D638	12.09
2	Elongation	%	ASTM D638	9.27
3	Hardness	Shore D	ASTM D2240	63, 62, 65

Disclaimer - 1: This report relates only to the particular sample submitted for test.
Disclaimer -2: Sampling is done by customer.
***END OF THE REPORT**

Fig 5.7 Test report

Fig: 5.8 Before Impact Test

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

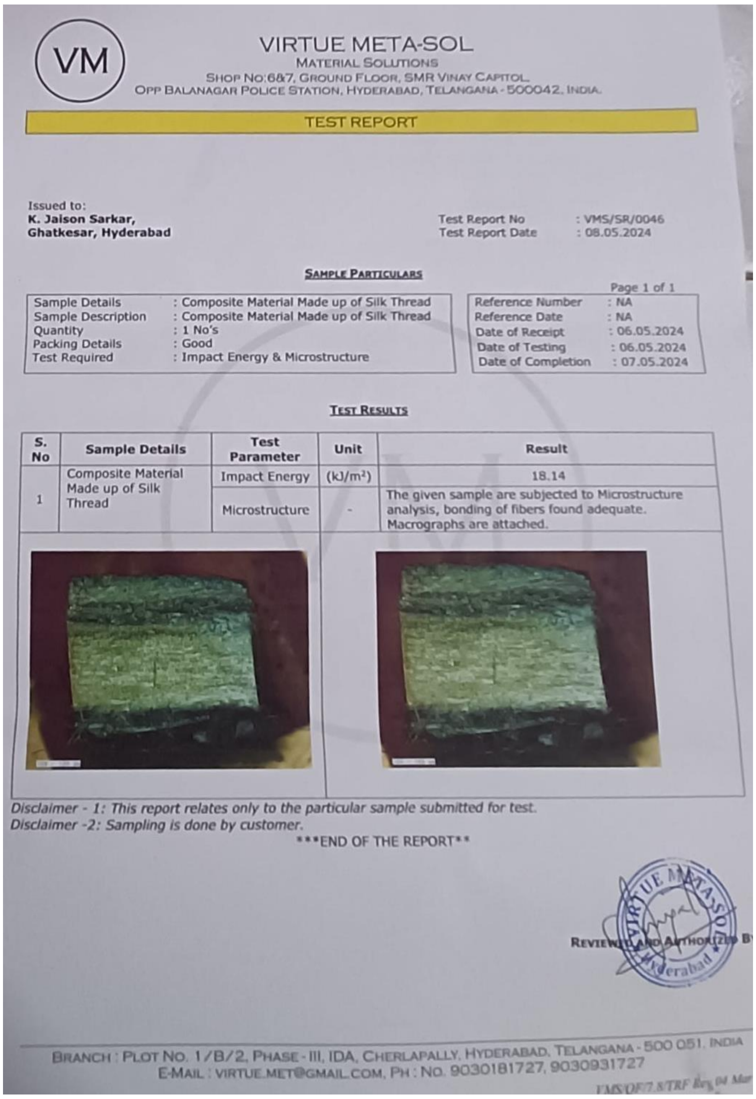
www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 05, May 2024, pp: 1986-1996

e-ISSN : 2583-1062

Impact Factor: 5.725

Fig: 5.9 After Impact Test



VIRTUE META-SOL
MATERIAL SOLUTIONS
SHOP NO:6&7, GROUND FLOOR, SMR VINAY CAPITOL,
OPP BALANAGAR POLICE STATION, HYDERABAD, TELANGANA - 500042, INDIA.

TEST REPORT

Issued to:
K. Jaison Sarkar,
Ghatkesar, Hyderabad

Test Report No : VMS/SR/0046
Test Report Date : 08.05.2024

SAMPLE PARTICULARS

Page 1 of 1

Sample Details	: Composite Material Made up of Silk Thread
Sample Description	: Composite Material Made up of Silk Thread
Quantity	: 1 No's
Packing Details	: Good
Test Required	: Impact Energy & Microstructure

Reference Number	: NA
Reference Date	: NA
Date of Receipt	: 06.05.2024
Date of Testing	: 06.05.2024
Date of Completion	: 07.05.2024

TEST RESULTS

S. No	Sample Details	Test Parameter	Unit	Result
1	Composite Material Made up of Silk Thread	Impact Energy	(kJ/m^2)	18.14
		Microstructure	-	The given sample are subjected to Microstructure analysis, bonding of fibers found adequate. Macrographs are attached.

Disclaimer - 1: This report relates only to the particular sample submitted for test.
Disclaimer -2: Sampling is done by customer.

***END OF THE REPORT**

REVIEWED AND AUTHORIZED BY

BRANCH : PLOT NO. 1/B/2, PHASE - III, IDA, CHERLAPALLY, HYDERABAD, TELANGANA - 500 051, INDIA
E-MAIL : VIRTUE.MET@GMAIL.COM, PH : NO. 9030181727, 9030931727

Fig: 5.10 Test result

6. CONCLUSION

In conclusion, the fabrication of composite materials using silk cocoon threads presents a versatileand promising avenue for innovation across various industries. Through meticulous attention to detail and adherence to best practices, manufacturers can harness the unique properties of silk cocoon threads to create composite materials with exceptional strength, lightweight, flexibility, and biocompatibility.

This project has highlighted the comprehensive process involved in fabricating composite materials using silk cocoon threads, covering crucial aspects such as material selection, preparation, impregnation, curing, and quality control. Additionally, it has explored various testingmethods and considerations, including tensile testing, elongation testing, hardness testing, microstructure testing, as well as safety and environmental considerations.

The wide range of applications for these composite materials, spanning aerospace, automotive, biomedical, sporting goods, architectural, and construction industries, underscores their versatilityand potential impact. Furthermore, the future scope of research and development offers exciting opportunities for advanced manufacturing techniques, functionalization, biomedical innovations, sustainable materials development, and integration of smart materials.

It is essential to emphasize the importance of safety and environmental considerations throughoutthe fabrication process and product life cycle. By prioritizing safety measures, selecting eco- friendly materials, and adopting sustainable practices, manufacturers can ensure the responsible production and use of composite materials fabricated using silk cocoon threads, thereby contributing to a more sustainable and environmentally conscious future.

In summary, the fabrication of composite materials using silk cocoon threads represents aconvergence of tradition and innovation, offering endless possibilities for enhancing performance,efficiency, and sustainability across industries. With continued research, collaboration, and technological advancement, these composite materials are poised to revolutionize various sectorsand drive positive change in the global landscape.

7. REFERENCES

[1] Singh, R., & Sagar, M. P. (2023). "Protein composites from silkworm cocoons as versatile biomaterials." ScienceDirect.

[2] Ling, S., & Kaplan, D. L. (2023). "Silk-based bioinspired structural and functional materials." ScienceDirect.

[3] Zhan, Y., et al. (2024). "Flat-Silk-Cocoon-Based Wearable Flexible Piezoresistive Sensor and Its Performance." Polymers.

[4] Mahesh, S., & Venkatesh, R. (2023). "Review on Fabrication and Application of Regenerated Bombyx mori Silk." De Gruyter.

[5] Park, J., & Lee, S. (2023). "Fabrication, Structure, and Properties of Nonwoven Silk Fabrics Prepared with Different Cocoon Layers." International Journal of Molecular Sciences.

[6] Rajkhowa, R., et al. (2023). "Optimization of mechanical properties of silk fiber-reinforced composites." SAGE Journals.

[7] Chen, X., & Shao, Z. (2023). "Silk microfiber-reinforced silk composite scaffolds: Fabrication and evaluation." Springer.

[8] Zhang, X., et al. (2023). "Design and Fabrication of Silk Templated Electronic Yarns and Textiles." ScienceDirect.

[9] Jovicic, D., et al. (2024). "Antibiotics-free wound dressing combating bacterial infections using silk cocoon shells." ScienceDirect.

[10] Wang, Y., & Cheng, Q. (2023). "Polypyrrole coated silk fibroin microfibers for wearable sensors." Elsevier.

[11] Yao, J., et al. (2023). "Synthesis and application of silk fibroin-based nanocomposites." Wiley Online Library.

[12] Li, C., et al. (2023). "Fabrication of silk fiber-based composite sponges for efficient oil-water separation." Springer.

[13] Guo, J., et al. (2023). "Electrospun silk fibroin nanofibers for tissue engineering applications." MDPI.

[14] Tang, S., et al. (2024). "Development of bio-based composites using silk fibroin and natural polymers." Springer.

[15] Wu, X., & Huang, Y. (2023). "Characterization of silk fibroin-based biodegradable composites." Elsevier.

[16] Chen, Z., et al. (2023). "Preparation and properties of silk fibroin/hydroxyapatite composite scaffolds." Wiley Online Library.

[17] Fan, L., & Gao, C. (2023). "Biodegradable silk fibroin-based hydrogels for drug delivery." MDPI.

[18] Zhao, Y., et al. (2023). "Enhancing the mechanical properties of silk fibroin films with graphene oxide." ScienceDirect.

[19] Wang, F., et al. (2023). "Development of silk fibroin-based films for food packaging applications." Springer.

[20] Kim, H., & Park, K. (2023). "Electrochemical sensors based on silk fibroin composites for biomedical applications." Wiley Online Library.