

**INVESTIGATION OF THE INFLUENCE OF THE
PROCESS PARAMETER ON THE NATURAL FIBER
POLYMER COMPOSITE**

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering degree in
Mechanical Engineering

By

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(DEEMED TO BE UNIVERSITY)

Accredited with grade “A++” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of HANAN GEOFFREY ABRAHAM (Reg.No.40150010) and SRIRAM. R (Reg.No.40150045) who carried out the project entitled **"INVESTIGATION OF THE INFLUENCE OF THE PROCESS PARAMETER ON THE NATURAL FIBER POLYMER COMPOSITE"** under our supervision from December 2023 to April 2024.

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ABSTRACT

This research focuses on meticulously examining the influence of various process parameters on the properties and characteristics of natural fiber polymer composites. With the escalating interest in eco-friendly materials, natural fiber composites have emerged as a promising alternative across diverse industries. However, the challenge persists in optimizing the manufacturing process to attain the desired mechanical and thermal properties. Through a methodical approach of experimentation and analysis, this study endeavors to shed light on the intricate relationship between key process parameters such as temperature, pressure, moisture content, and fiber orientation, and their impact on the performance of these composites. By comprehensively investigating these factors, the aim is to uncover insights that could significantly contribute to enhancing the manufacturing process of natural fiber polymer composites. Employing a blend of experimental techniques including material characterization and mechanical testing, this investigation aims to provide a holistic assessment of the effects of process parameters on composite properties. Concurrently, mechanical testing, encompassing tensile, flexural, and impact assessments, will be conducted to evaluate properties like strength, stiffness, and toughness under varying processing conditions. By delving into these aspects, the findings of this study are poised to offer invaluable insights into optimizing the manufacturing process of natural fiber polymer composites, thereby fostering the development of superior composite materials tailored for a spectrum of industrial applications.

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LIST OF SYMBOLS AND ABBEREVIATIONS

NFC	Natural Fiber Composite
P1	Plate 1 (Stacked composite of Pineapple-Bamboo-Pineapple)
P2	Plate 2 (Stacked composite of Bamboo-Pineapple-Bamboo)

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CHAPTER 1 INTRODUCTION

Over the past few decades, natural fiber composites (NFCs) have gradually emerged as a viable alternative to traditional polymer composites in various engineering applications. The incorporation of natural fibers, or plant cellulosic fibers, in composite materials represents a promising avenue for innovation and advancement in various industries. This shift is driven by their cost-effectiveness and satisfactory mechanical properties. There is a burgeoning interest in the potential to develop bio-composites with minimal environmental impact, aiming to achieve carbon dioxide neutrality. Among the myriad natural fibers available, pineapple fiber and bamboo fiber stand out for their unique properties and abundance in certain regions. Pineapple fiber, extracted from the leaves of the pineapple plant, and bamboo fiber, derived from the bamboo plant, offer promising characteristics such as high strength-to-weight ratio, renewability, biodegradability, and low cost.

The fabrication of NFPCs involves the integration of natural fibers within a polymer matrix, typically through processes like compression molding, injection molding, and extrusion. However, the properties of NFPCs depend not only on the choice of fibers and polymer matrix but also on various process parameters employed during fabrication. These parameters include temperature, pressure, fiber orientation, fiber content, molding time, and cooling rate, among others.

Understanding the influence of these process parameters on the properties of NFPCs is crucial for optimizing their performance and expanding their applications. By systematically investigating how variations in these parameters affect the mechanical, thermal, and morphological properties of pineapple and bamboo fiber composites, researchers and manufacturers can tailor NFPCs to meet specific application requirements.

In this report, we will explore the current state of research on the influence of process parameters on the properties of NFPCs containing pineapple and bamboo fibers. We will review studies that have examined the effects of different processing conditions on the mechanical strength, thermal stability, water absorption, and other key properties of these composites. Additionally, we will highlight gaps in existing knowledge and propose areas for further investigation to advance the understanding and utilization of pineapple and bamboo fiber polymer composites.

1.1 BACKGROUND OF STUDY

Natural fiber polymer composites (NFPCs) have gained significant attention in recent years as sustainable alternatives to conventional synthetic composites. Pineapple fiber and bamboo fiber, owing to their abundance, low cost, and desirable mechanical properties, have emerged as promising reinforcements for polymer matrices. Comparison between natural fibers and other reinforced composites underscores the superior characteristics exhibited by natural fibers, particularly in industrial applications. However, the successful fabrication of high-quality NFPCs hinges on optimizing various process parameters during manufacturing.

One method of fabricating NFPCs is vacuum bagging, a composite manufacturing technique widely used for its simplicity and effectiveness in producing laminated structures with good fiber alignment and consolidation. Vacuum bagging involves placing layers of fibers and resin in a mold, sealing the assembly with a flexible vacuum bag, and applying vacuum pressure to remove air and ensure uniform resin impregnation. While vacuum bagging offers several advantages such as cost-effectiveness, scalability, and versatility, the influence of process parameters on the properties of NFPCs fabricated through this method remains an area of active research.

Several studies have investigated the effects of vacuum bagging parameters on NFPCs, albeit predominantly with synthetic fibers. However, there is a paucity of research specifically focusing on the influence of process parameters on NFPCs containing pineapple and bamboo fibers fabricated via vacuum bagging. Understanding how parameters such as vacuum pressure, curing temperature, curing time, fiber arrangement, and resin type affect the mechanical, thermal, and

morphological properties of pineapple and bamboo fiber composites is essential for optimizing their fabrication process and enhancing their performance.

By systematically exploring the interplay between process parameters and composite properties in vacuum bagged NFPCs comprising pineapple and bamboo fibers, researchers can advance the knowledge base in this area and contribute to the development of sustainable composite materials. Furthermore, this research can inform manufacturers and engineers in selecting optimal process conditions to produce NFPCs tailored to specific application requirements, thereby promoting the adoption of eco-friendly materials in various industries.

CHAPTER 2

LITERATURE SURVEY

2.1 OVERVIEW OF NATURAL FIBER COMPOSITES

Natural fiber composites (NFCs) are composite materials that combine natural fibers with polymer matrices to create a sustainable and environmentally friendly alternative to traditional synthetic fiber composites. NFCs offer several advantages, including biodegradability, renewability, low cost, reduced carbon footprint, and comparable mechanical properties to synthetic composites. This overview will discuss the characteristics, manufacturing processes, properties, and applications of NFCs, with references to key studies in the field.

2.2 CHARACTERISTICS OF NATURAL FIBERS

Natural fibers used in NFCs are derived from renewable resources such as plants (e.g., jute, hemp, sisal, flax, bamboo) and animals (e.g., wool, silk). These fibers exhibit unique properties such as high strength-to-weight ratio, low density, biodegradability, and sustainability. For example, bamboo fibers are known for their exceptional strength and stiffness, while jute fibers offer good tensile strength and abrasion resistance.

2.3 MAUFACTURING PROCESS

NFCs can be manufactured using various processes, including compression molding, injection molding, extrusion, and vacuum bagging. The choice of manufacturing process depends on factors such as fiber type, polymer matrix, desired properties, and end-use applications. In the realm of thermoplastic matrices, compression molding emerges as a widely employed technique, particularly in the context of utilizing unfastened chopped fibers or mats composed of short and long fibers. These fiber configurations may exhibit either a highly irregular or deliberately aligned structure, offering versatility in adapting to specific application requirements. For instance, compression molding is commonly used for producing NFCs with thermosetting polymers, while injection molding offers high production efficiency for complex-shaped parts.

2.4 PROPERTIES OF NFC

The properties of NFCs depend on several factors, including fiber type, fiber content, fiber-matrix adhesion, manufacturing process, and composite architecture. NFCs typically exhibit good mechanical properties, such as tensile strength, flexural strength, and impact resistance, comparable to synthetic fiber composites. Moreover, NFCs offer advantages such as low density, thermal insulation, acoustic damping, and biodegradability, making them suitable for various applications.

2.5 APPLICATION OF NFC

NFCs find applications across diverse industries, including automotive, aerospace, construction, packaging, furniture, and consumer goods. In automotive applications, NFCs are used for interior components, door panels, and structural reinforcements to reduce vehicle weight and improve fuel efficiency. Extending beyond automotive applications, the aerospace sector has acknowledged the merits of NFCs, incorporating them into aircraft interior paneling to leverage their unique combination of properties, including strength and environmental considerations. In construction, NFCs are employed for building materials, such as roofing tiles, flooring, and wall panels, due to their thermal insulation and sustainability. The utilization of composite materials in the production of sports equipment underscores their versatility and adaptability, contributing to enhanced performance and durability across various athletic pursuits.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The objective of this investigation is to systematically analyze the influence of various process parameters on the properties of natural fiber polymer composites (NFPCs) consisting of pineapple fiber and bamboo fiber, specifically fabricated using the vacuum bagging process. The primary goal is to understand how different vacuum bagging parameters impact the mechanical, thermal, and morphological characteristics of the NFPCs. This study aims to provide valuable insights into optimizing the vacuum bagging process for the production of high-performance NFPCs, thereby advancing the utilization of sustainable composite materials in various industries.

3.2 SCOPE OF THE PROJECT

3.2.1 Process Parameters

The investigation will focus on analyzing a range of process parameters relevant to the vacuum bagging process, including vacuum pressure, curing temperature, curing time, fiber arrangement, resin type, and fiber-matrix interaction. This investigation seeks to systematically vary and analyze key process parameters including fiber content, pressure, temperature, and processing time. By meticulously controlling and manipulating these parameters, we aim to gain a nuanced understanding of their individual and combined effects on the properties of the resulting composite materials.

3.2.2 Material Selection

The study will utilize pineapple fiber and bamboo fiber as reinforcement materials, with a selected polymer matrix suitable for vacuum bagging applications. The choice of materials will be based on their availability, compatibility with the vacuum bagging process, and potential for enhancing composite properties. By harnessing renewable resources and employing eco-friendly manufacturing processes, the aim is to promote the adoption of greener alternatives to conventional synthetic composites, aligning with the broader goal of sustainability in materials science and engineering.

3.2.3 Mechanical Properties

The mechanical properties of the NFPCs, such as tensile strength, flexural strength, impact strength, and hardness, will be evaluated to assess the effects of process parameters on the structural performance of the composites.

3.2.4 Enhance Structural Properties

By elucidating the relationship between process parameters and composite properties, the aim is to enhance the structural characteristics of the composite materials. This involves seeking ways to improve tensile strength, flexural strength, impact resistance, thermal stability, and the quality of the fiber-matrix interface, thereby advancing the overall performance of the composites.

3.2.5 Optimization

The study will aim to identify optimal vacuum bagging parameters for achieving NFPCs with enhanced mechanical properties, thermal stability, and morphological characteristics. Recommendations for process optimization will be provided based on the experimental findings.

3.2.6 Application Potential

The investigation will discuss the potential applications of the optimized NFPCs in various industries, including automotive, construction, aerospace, and consumer goods, highlighting the benefits of using sustainable composite materials for lightweight, durable, and eco-friendly products.

In summary, this investigation aims to provide valuable insights into the optimization of process parameters for natural fiber polymer composites, particularly utilizing pineapple fiber and bamboo fiber reinforcements with the vacuum bagging production process. Through a systematic and detailed exploration of these parameters, the aim is to advance the development of high-performance, sustainable composite materials suitable for a diverse range of applications.

CHAPTER 4

MATERIALS AND EXPERIMENTAL METHOD

4.1 METHODOLOGY

4.1.1 Material Preparation

Fiber Extraction and Processing: Pineapple and bamboo fibers are extracted from their respective sources and processed to obtain uniform lengths. This may involve mechanical crushing, washing, and drying to remove impurities and achieve consistent fiber dimensions.

Resin Matrix Preparation: A suitable polymer resin matrix, such as epoxy or polyester, is prepared according to manufacturer guidelines. The resin may be mixed with additives or fillers to enhance properties such as adhesion, toughness, or flame resistance.

4.1.2 Composite Layup Preparation

Design of Composite Layup: The desired fiber orientation and stacking sequence are determined based on the intended application and performance requirements.

Layer Arrangement: Layers of pineapple and bamboo fibers are arranged alternately with resin matrix in a mold, ensuring even distribution and alignment of fibers throughout the composite structure.

Vacuum Bagging Setup: The composite layup is placed in a vacuum bag, and any necessary inserts or peel plies are added to facilitate resin flow and air removal during the vacuum bagging process.

4.1.3 Vacuum Bagging Production Process

Preparation of Mold:

- Clean and prepare the mold surface to ensure proper adhesion and release of the composite laminate.
- Apply mold release agent or mold release film to facilitate easy removal of the cured composite.



Fig 4.1 Preparation of Mold

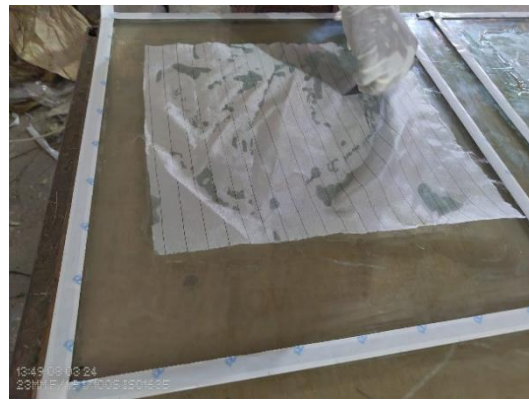


Fig 4.2 Preparation of Mold

Layup of Fiber Reinforcements:

- Arrange the pre-cut pineapple and bamboo fibers according to the desired orientation and layup sequence.
- Alternate layers of fiber reinforcements with resin matrix to achieve the desired fiber-to-resin ratio and laminate thickness.
- Ensure proper alignment and consolidation of fiber layers to minimize voids and ensure uniform resin impregnation.



Fig 4.3 Layup of Fiber Reinforcements



Fig 4.4 Layup of Fiber Reinforcement

Resin Infusion:

- Apply resin to the dry fiber reinforcement using methods such as hand layup, resin infusion, or resin transfer molding (RTM).
- Use rollers or brushes to evenly distribute the resin and impregnate the fibers, ensuring thorough wetting and saturation of the reinforcement.



Fig 4.5 Resin Infusion



Fig 4.6 Resin Infusion

Assembly of Vacuum Bagging Materials:

Place a release film over the resin-infused laminate to prevent the resin from sticking to the breather cloth.

Position a breather cloth on top of the release film to absorb excess resin and facilitate air evacuation.

Carefully position the vacuum bagging film over the entire layup, ensuring there are no wrinkles or folds that could compromise the vacuum seal.



Fig 4.7 Vacuum Bagging Assembly



Fig 4.8 Vacuum Bagging Assembly

Sealing and Evacuation:

Use sealant tape to create a tight seal around the perimeter of the vacuum bagging film, ensuring an airtight enclosure.

Connect the vacuum pump to the vacuum bag and initiate the vacuum process, gradually evacuating air from the bag.

Monitor the vacuum pressure and ensure that it reaches the desired level to promote resin flow and consolidation of the laminate.



Fig 4.9 Sealing and Evacuation

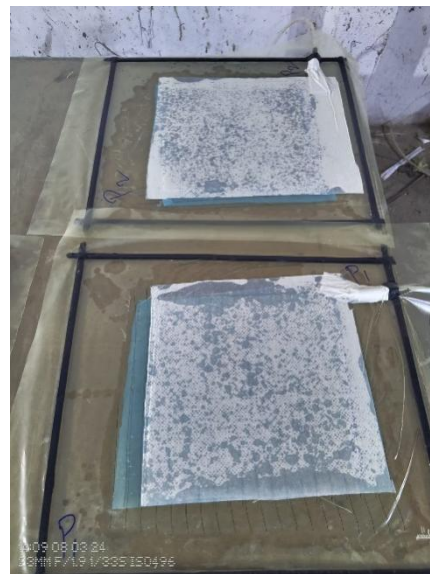


Fig 4.10 Sealing and Evacuation

Curing and Consolidation:

Transfer the vacuum bagged composite layup to a temperature-controlled curing environment, such as an oven or autoclave.

Follow the prescribed curing cycle, including ramp-up, dwell, and cool-down phases, to ensure proper polymerization and consolidation of the composite.

Monitor temperature and pressure throughout the curing process to prevent overheating or loss of vacuum pressure.

Demolding and Finishing:

After curing, carefully remove the vacuum bagging materials and demold the cured composite laminate from the mold or tooling.

Trim excess material and perform any necessary finishing operations, such as sanding or machining, to achieve the final dimensions and surface quality of the composite part.

By following these steps, manufacturers can effectively utilize the vacuum bagging process to produce high-quality pineapple fiber and bamboo fiber composites with desired mechanical properties and surface finish

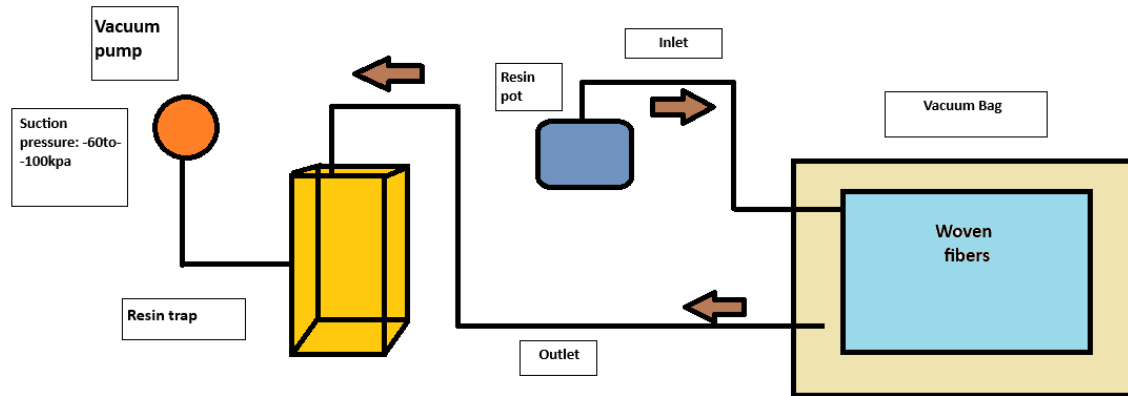


Fig 4.11 Vacuum Bagging Process

4.1.4 Process Parameter Variation

Fiber Content Variation:

Different compositions of pineapple and bamboo fibers are tested to determine the optimal fiber content for mechanical performance and structural integrity.

Pressure Variation:

The vacuum pressure level is adjusted to explore its influence on resin flow, fiber compaction, and void reduction during composite consolidation.

Temperature Variation:

Various curing temperatures are tested to investigate their effects on resin cure kinetics, composite strength, and thermal stability.

Processing Time Variation:

Different curing durations are examined to assess their impact on resin cure degree, composite bonding, and overall processing efficiency.

4.1.5 Testing and Analysis

Tensile Test:

- Pulling test to see how strong and stretchy a material is.
- Material sample is pulled apart by a machine.
- Shows how much force the material can take before breaking and how much it stretches.

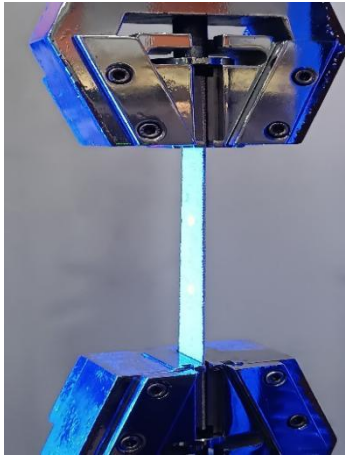


Fig 4.12 Tensile Test

Flexural Test:

- Bending test to check how well a material bends without breaking.
- Material is bent by a machine, like a diving board.
- Measures how strong and stiff the material is when bent.

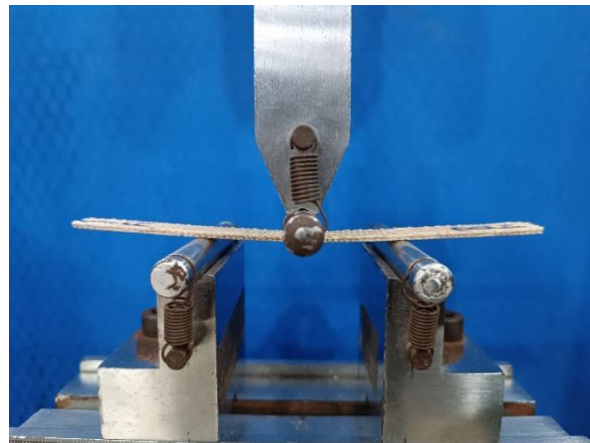


Fig 4.13 Flexural Test

Shore D Hardness Test:

- Test to see how hard or soft a material is.
- A probe is pushed into the material, and the depth of the indentation tells how hard the material is.
- Gives a number that shows how hard or soft the material feels.



Fig 4.14 Shore D Hardness Test

Izod Test:

- Test to check how well a material resists being hit or shocked.
- A swinging hammer hits a notched sample of the material, and the energy absorbed during the break is measured.
- Shows how tough the material is—how much energy it can absorb without breaking.

These tests help engineers understand how materials behave under different conditions, which is important for designing products that are strong, durable, and safe.

4.1.6 Data Interpretation and Optimization

- Experimental data is analyzed to identify trends, correlations, and optimal process parameters that lead to improved composite properties.
- Statistical tools and modeling techniques may be employed to optimize process conditions and predict composite performance based on experimental results.
- Iterative testing and refinement of process parameters may be conducted to further enhance the mechanical, thermal, and structural properties of the natural fiber polymer composites.

4.2 MATERIAL SELECTION

Pineapple fiber and bamboo fiber are two natural fibers gaining popularity in various industries due to their eco-friendly properties and versatile applications. Both fibers offer sustainable alternatives to synthetic materials, contributing to the growing trend of environmentally conscious consumerism.

4.2.1 Pineapple Fiber

Source:

Derived from the leaves of the pineapple plant (*Ananas comosus*).

Extraction:

Pineapple fibers are extracted through a process called decortication, which involves stripping the long fibers from the leaves.

Properties:

- Lightweight and flexible.
- High tensile strength.
- Breathable and moisture-wicking.
- Biodegradable and eco-friendly.

4.2.2 Bamboo Fiber

Source:

Derived from bamboo plants, particularly the Moso bamboo species (*Phyllostachys edulis*).

Extraction:

Bamboo fibers are extracted through mechanical or chemical processes, including crushing the bamboo plant and then combing out the fibers mechanically or using chemicals to break down the plant material.

Properties:

- Soft and smooth texture.
- Naturally antibacterial and hypoallergenic.
- Absorbent and moisture-wicking.
- Durable and strong.
- Biodegradable and renewable.

4.2.3 Comparison

Sustainability:

Both pineapple and bamboo fibers are considered sustainable alternatives to conventional materials due to their renewable sources and biodegradability.

Strength:

Pineapple fiber generally has a higher tensile strength compared to bamboo fiber, making it suitable for applications requiring robust materials.

Softness:

Bamboo fiber is softer, and smoother compared to pineapple fiber, offering comfort in textiles and clothing.

Processing:

Bamboo fiber requires less chemical processing compared to pineapple fiber, which might involve more intensive processing for extraction.

4.2.4 Conclusion:

Pineapple fiber and bamboo fiber represent sustainable alternatives to traditional materials, offering a combination of strength, comfort, and eco- friendliness. Their versatility and environmentally friendly properties make them increasingly popular choices across various industries, contributing to the global shift towards sustainable practices.



Fig 4.15 Pineapple Mat



Fig 4.16 Bamboo Mat

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Result

The investigation into the influence of process parameters on natural fiber polymer composites, specifically utilizing pineapple fiber and bamboo fiber with the vacuum bagging production process, yielded significant findings

5.1.1 Izod Impact Test

- Plate 1 Composite: Izod impact strength measured 50.7 J/m.
- Plate 2 Composite: Izod impact strength measured 54.6 J/m.

Length (mm) :	66.06
Width (mm) :	10.14
Thickness (mm) :	1.97
Scale / Hammer :	1

Table 5.1: P1 Dimensions

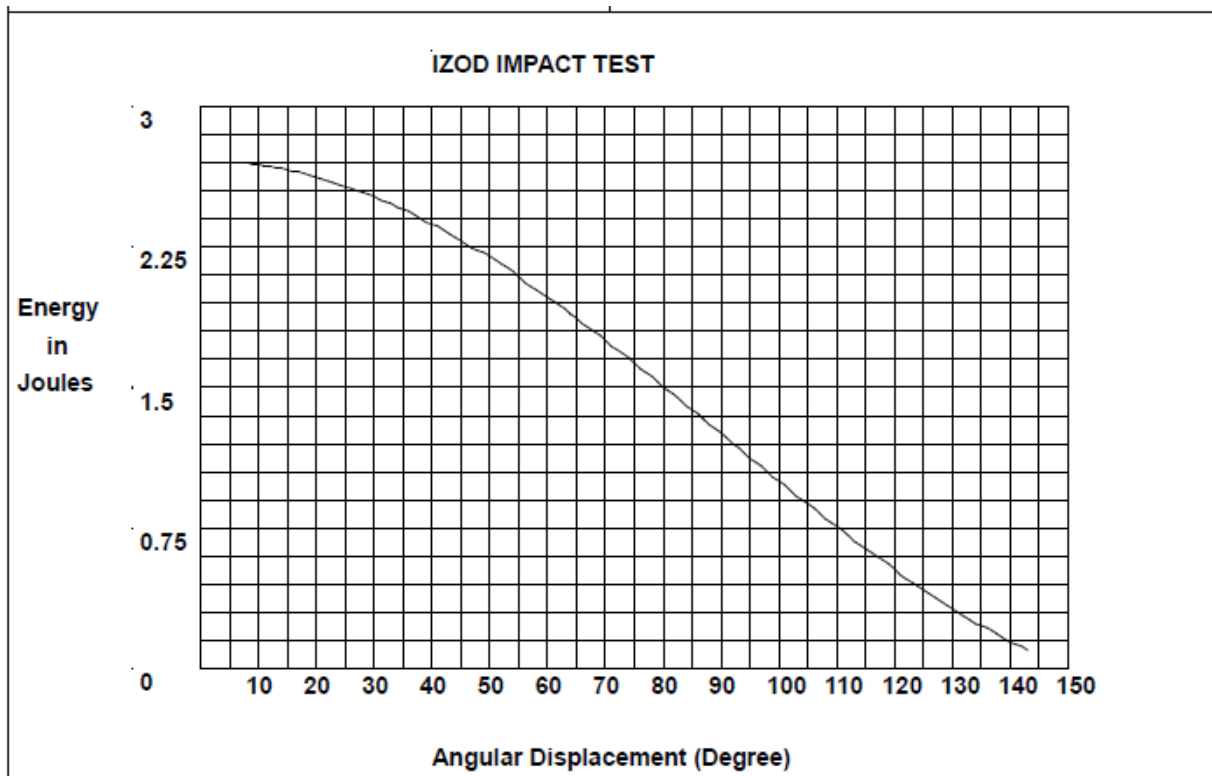


Fig 5.1: Izod Test P1

RESULT			
Izod Impact energy : 0.1 Joules			
	j/m	kg.cm/cm	kg.m/m
Izod Impact strength as per (ASTM Standard):	50.7	5.17	5.17
	j/mm ²	j/cm ²	kJ/m ²
Izod Impact strength as per (IS / ISO Standard):	0.005	0.5	5

Table 5.2: Izod Test P1

Length (mm) :	65.92
Width (mm) :	10.16
Thickness (mm) :	1.83
Scale / Hammer :	1

Table 5.3: P2 Dimensions

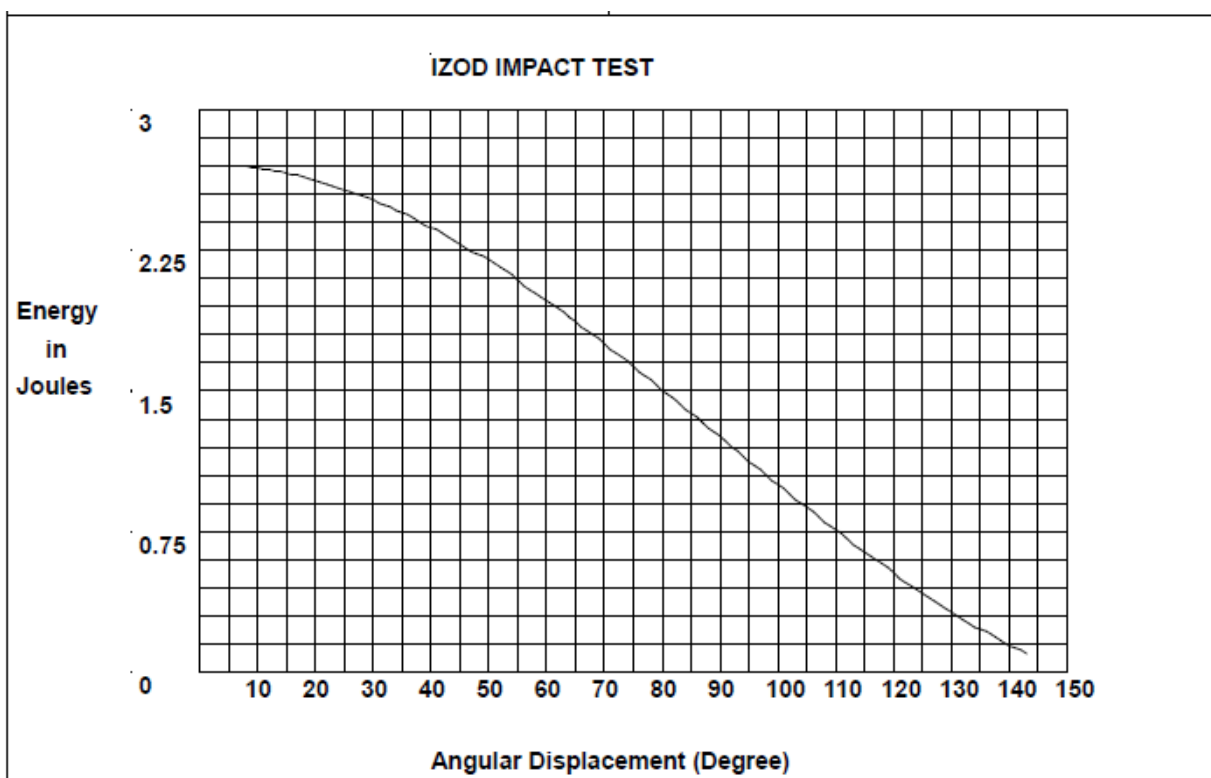


Fig 5.2: Izod Test P2

RESULT			
Izod Impact energy : 0.1 Joules			
	j/m	kg.cm/cm	kg.m/m
Izod Impact strength as per (ASTM Standard):	54.6	5.57	5.57
	j/mm ²	j/cm ²	kJ/m ²
Izod Impact strength as per (IS / ISO Standard):	0.005	0.537	5.37

Table 5.4: Izod Test P2

Comparison

Bamboo silk composite displayed higher hardness values compared to pineapple silk composite, suggesting greater resistance to indentation or penetration. This implies that bamboo silk composite may be better suited for applications requiring resistance to wear, abrasion, or surface damage. The higher hardness of bamboo silk composite suggests that it could withstand harsher environments or repetitive mechanical actions without undergoing significant deformation or damage.

Therefore, in scenarios where hardness and durability are important factors, such as in flooring materials, tool components, or protective coatings, bamboo silk composite may offer a more resilient solution compared to pineapple silk composite.

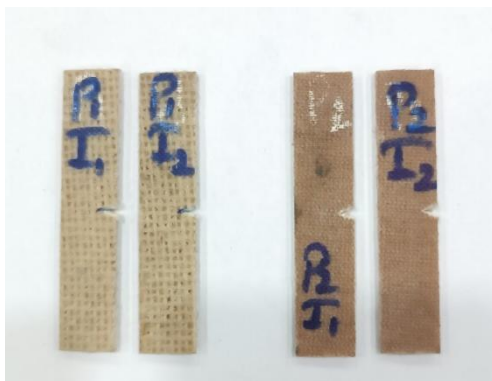


Fig 5.3: Izod Specimen (Before Test)



Fig 5.4 Izod Specimen (After Test)

5.1.2 Shore Hardness Test

- Plate 1 Composite: Shore hardness measured 85 on the Shore scale.
- Plate 2 Composite: Shore hardness measured 87 on the Shore scale.

S.No	Hardness (SHORE D)
P1H1	85
P1H2	85
P2H1	87
P2H2	87

Table 5.5: Hardness Test for P1 and P2

Comparison

Bamboo silk composite displayed higher hardness values compared to pineapple silk composite, suggesting greater resistance to indentation or penetration. This implies that bamboo silk composite may be better suited for applications requiring resistance to wear, abrasion, or surface damage. The higher hardness of bamboo silk composite suggests that it could withstand harsher environments or repetitive mechanical actions without undergoing significant deformation or damage.

Therefore, in scenarios where hardness and durability are important factors, such as in flooring materials, tool components, or protective coatings, bamboo silk composite may offer a more resilient solution compared to pineapple silk composite.

5.1.3 Flexural Test

- Plate 1 Composite: Flexural strength measured 4630.547 MPa.
- Plate 2 Composite: Flexural strength measured 3723.943 MPa.

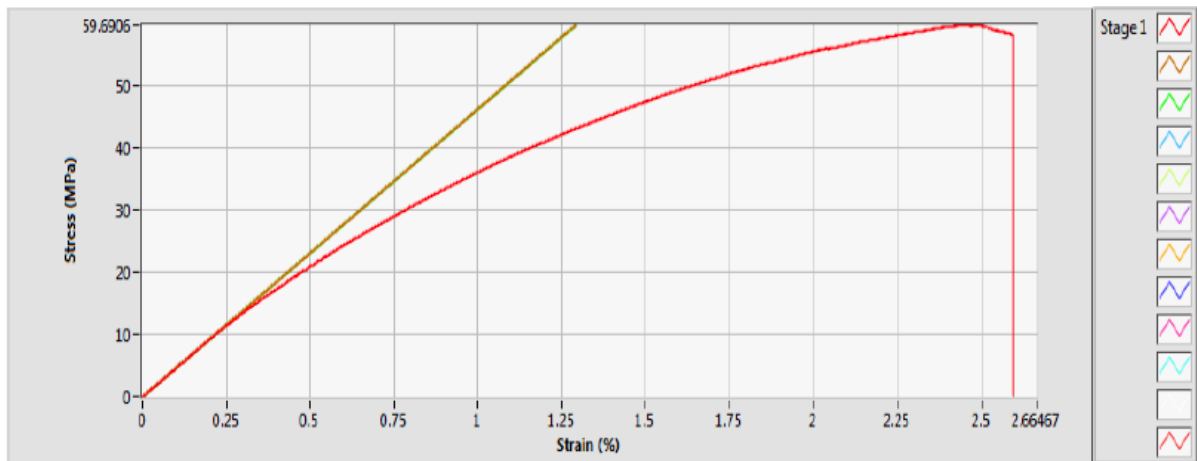


Fig 5.5: Flexural Test P1

Specimen	Batch	Date & Time	Width (mm)	Thickness (mm)	Span Length (mm)	Flex Strength (MPa)	Flex Mod (MPa)
Total 1	Name	Time	mm	mm	mm	MPa	MPa
Spec:0001	15215 (Hayael)	16/03/24_17:35	13.889	2.096	68.000	59.691	4630.547

Table 5.6: Flexural Test P1

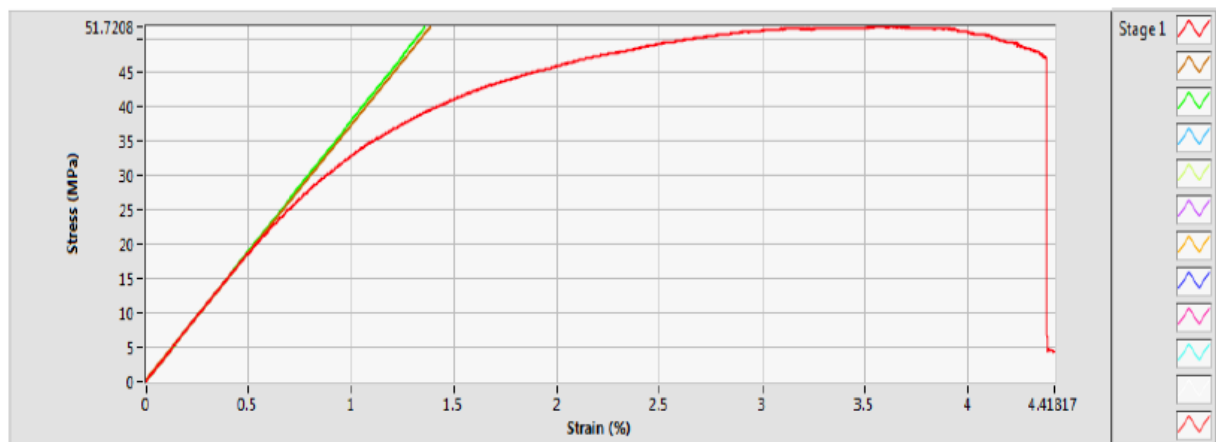


Fig 5.6: Flexural Test P2

Specimen	Batch	Date & Time	Width (mm)	Thickness (mm)	Span Length (mm)	Flex Strength (MPa)	Flex Mod (MPa)
Total 1	Name	Time	mm	mm	mm	MPa	MPa
Spec:0004	15215 (Hayael)	16/03/24_17:50	13.955	1.914	62.000	51.721	3723.943

Table 5.7: Flexural Test P2

Comparison

Bamboo silk composite demonstrated higher flexural strength than pineapple silk composite, indicating better resistance to bending forces. This suggests that

bamboo silk composite may be more suitable for applications subjected to bending or flexing loads, such as structural components, furniture, or construction materials. The higher flexural strength of bamboo silk composite implies greater structural integrity and durability, reducing the risk of deformation or failure under bending stresses. Therefore, in scenarios where resistance to bending forces is crucial, bamboo silk composite may offer a more reliable and long-lasting solution compared to pineapple silk composite.



Fig 5.7: Flexural Specimen (Before Test)

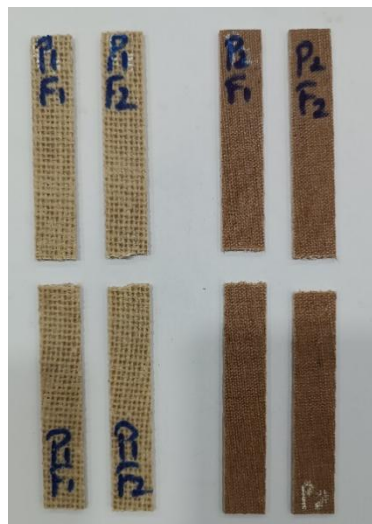


Fig 5.8: Flexural Specimen (After Test)

5.1.4 Tensile Test

- Plate 1 Composite: Tensile strength measured 36.291 MPa.
- Plate 2 Composite: Tensile strength measured 46.744 MPa.

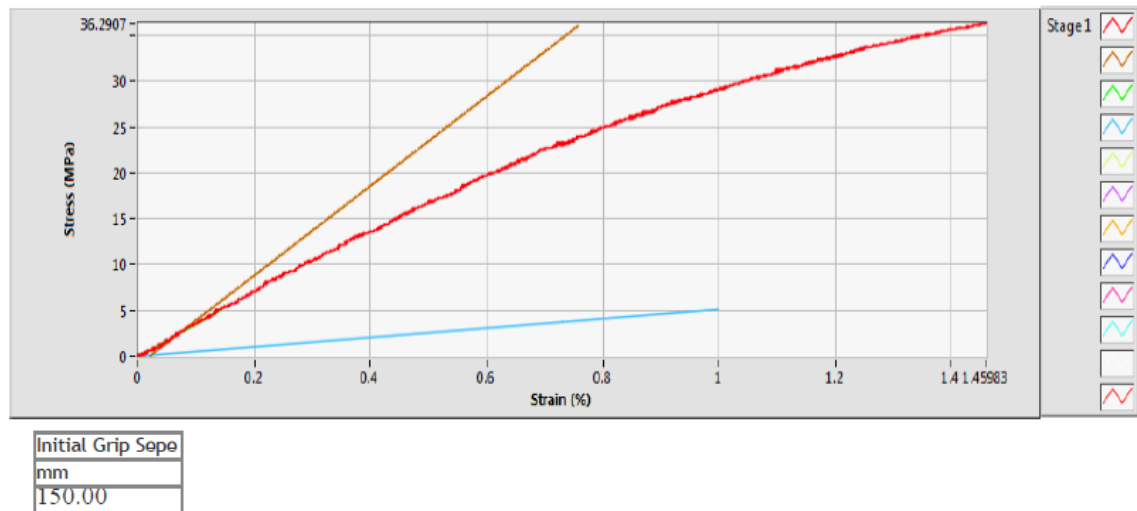


Fig 5.9: Tensile Test P1

Specimen	Batch	Date & Time	CSA	Width	Thickness	Gauge Length	Tensile Strength
Total 1	Name	Time	sq.mm	mm	mm	mm	MPa
Spec:0001	15215 (Hayael)	16/03/24_17:00	53.076	25.740	2.062	49.4165	36.291

Specimen	Peak Load	Elongation@Bre	Stress@Break	Elongation@Yie	Stress @ Yield	NS@Break	Parallel Length
Total 1	N	%	MPa	%	MPa	%	mm
Spec:0001	1926.161	1.460	36.291	1.460	36.291	1.937	150.00

Table 5.8: Tensile Test P1

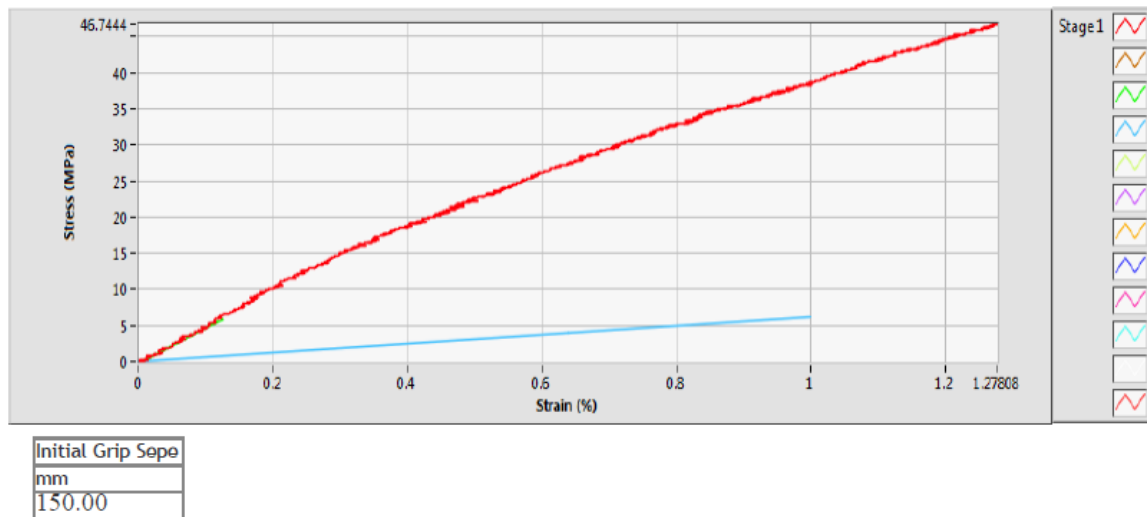


Fig 5.10: Tensile Test P2

Specimen	Batch	Date & Time	CSA	Width	Thickness	Gauge Length	Tensile Strength
Total 1	Name	Time	sq.mm	mm	mm	mm	MPa
Spec:0003	15215 (Hayael)	16/03/24_17:10	50.905	25.840	1.970	49.6054	46.744

Specimen	Peak Load	Elongation@Break	Stress@Break	Elongation@Yield	Stress @ Yield	NS@Break	Parallel Length
Total 1	N	%	MPa	%	MPa	%	mm
Spec:0003	2379.512	1.278	46.744	1.278	46.744	2.015	150.00

Table 5.9: Tensile Test P2

Comparison

Bamboo silk composite exhibited higher tensile strength compared to pineapple silk composite, indicating better resistance to pulling forces. This implies that bamboo silk composite may be more suitable for applications requiring high tensile strength, such as in load-bearing structures, textiles, or ropes. The higher tensile strength of bamboo silk composite suggests that it can withstand greater pulling forces without breaking or deforming, making it more reliable in applications where mechanical strength is paramount. Therefore, in scenarios where resistance to pulling forces is a critical requirement, bamboo silk composite may offer a superior solution compared to pineapple silk composite.



Fig 5.11 Tensile Specimen (Before Test)



Fig 5.12 Tensile Specimen (After Test)

5.2 Discussion:

5.2.1 Impact Resistance

Bamboo silk composite showed superior impact strength compared to pineapple silk composite, making it more suitable for applications requiring resistance to sudden impacts or shocks. This suggests that bamboo silk composite may offer increased durability and reliability in environments where accidental impacts or high-velocity forces are common. For example, in industries such as automotive manufacturing, where components are subject to potential collisions or impacts, bamboo silk composite materials could provide enhanced protection against damage or failure.

5.2.2 Hardness

Bamboo silk composite displayed higher Shore hardness values compared to pineapple silk composite, indicating greater resistance to indentation or penetration. This suggests that bamboo silk composite may be more suitable for applications where hardness is critical, such as in flooring materials, cutting tools, or protective coatings. The higher hardness of bamboo silk composite implies improved wear resistance and longevity, making it a preferred choice for applications subjected to abrasive or repetitive mechanical actions.

5.2.3 Flexural Strength

Bamboo silk composite exhibited higher flexural strength, indicating better resistance to bending forces. This makes it suitable for applications subjected to

bending or flexing loads, such as structural components, furniture, or construction materials. The higher flexural strength of bamboo silk composite implies greater structural integrity and durability, reducing the risk of deformation or failure under bending stresses. Therefore, bamboo silk composite materials may offer enhanced reliability and longevity in applications where resistance to bending forces is crucial.

5.2.4 Tensile Strength

Bamboo silk composite demonstrated higher tensile strength compared to pineapple silk composite, indicating better resistance to pulling forces. This suggests that bamboo silk composite may be more suitable for applications requiring high tensile strength, such as load-bearing structures, textiles, or ropes. The higher tensile strength of bamboo silk composite implies improved structural stability and reliability, making it a preferred choice for applications where withstanding pulling forces is essential.

In conclusion, bamboo silk natural fiber polymer composites generally exhibited superior mechanical properties compared to pineapple silk composites across various tests including impact resistance, hardness, flexural strength, and tensile strength. These results highlight the potential of bamboo silk composite materials to offer enhanced performance and reliability in a wide range of applications, thereby guiding material selection decisions based on specific mechanical performance requirements.

CHAPTER 6

SUMMARY AND CONCLUSION

Throughout this session, we have explored the investigation of the influence of process parameters on natural fiber polymer composites, focusing on pineapple fiber and bamboo fiber reinforcements using the vacuum bagging production process. Here's a summary of the key points discussed:

6.1 Research Topic

The investigation aimed to understand how variations in process parameters affect the mechanical, thermal, and structural properties of natural fiber polymer composites, specifically using pineapple fiber and bamboo fiber reinforcements.

6.2 Methodology

The methodology involved material preparation, composite layup preparation, vacuum bagging production process, variation of process parameters, testing and analysis (including mechanical testing, thermal analysis, and microstructural analysis), data interpretation, and documentation/reporting.

6.3 Salient Features

The salient features of the investigation included the use of natural fiber reinforcements (pineapple and bamboo fibers), the vacuum bagging production method, and the systematic exploration of process parameters such as fiber content, pressure, temperature, and processing time.

6.4 Results and Discussion

The results showed that bamboo fiber composites generally exhibited superior mechanical properties (impact resistance, hardness, flexural strength, and tensile strength) compared to pineapple fiber composites. These findings suggest that bamboo fiber composites may offer enhanced performance and reliability for various applications.

6.5 Comparison and Conclusion

In summary, the investigation highlighted the potential of bamboo fiber composites as high-performance materials for applications requiring superior mechanical properties. The results can guide material selection and process optimization to develop sustainable and high-performance composite materials suitable for diverse industrial applications.

Ultimately, the integration of natural fibers like bamboo into polymer composites holds promise for the development of eco-friendly, high-performance materials that meet the demands of diverse industrial sectors while promoting sustainability and environmental stewardship.

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