FABRICATION AND CHARACTERIZATION OF NATURAL CONVECTION, FORCED CONVECTION AND MECHANICALPROPERTIES FOR NATURAL FIBER REINFORCED COMPOSITES

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Abstract –

Natural fiber-reinforced composites have gained popularity due to its environmental friendliness and biodegradability. The manufacture and characterization of composites employing banana fibers, wood powder, rice husk, and coconut leaf mid ribs with epoxy resins and flame retardants is investigated in this work. The procedure includes treating natural fibers, improving composite compositions, and integrating flame retardants to improve fire resistance without sacrificing mechanical strength.
The heat transfer properties of the composites' natural and forced convection behaviors are explored, while detailed mechanical testing analyses their strength, stiffness, and toughness. The results demonstrate that banana fiber and wood powder composites perform well in terms of natural convection and mechanical characteristics, making them appropriate for structural applications. Rice husk and coconut leaf mid rib composites have high thermal conductivity, making them suitable for heat dissipation.

This study adds to the development of sustainable materials and highlights possible applications in the construction, automotive, and electronics sectors, where mechanical performance and thermal management are critical factors.

Keywords:- Fabrication, Characterization, Natural fiber-reinforced composites, Banana fiber, Wood powder, Rice husk, Coconut leaf mid rib, Epoxy resins, Flame retardant, Mechanical properties, Natural convection, Forced convection, Thermal conductivity, Heat dissipation, Fire resistance

Keywords – PMCs, MMCs, CMCs, C-C Composites, NFCs, FGCs

INTRODUCTION

Natural fiber-reinforced composites are biodegradable and environmentally beneficial alternatives to conventional materials. This research focuses on the manufacturing and characterization of composites made from banana fiber, wood powder, rice husk, and coconut leaf mid rib in conjunction with epoxy resins and flame retardants.

The study will look at thermal resistance for heat bearing and transfer, as well as mechanical qualities such as tensile and flexural strengths and impact resistance. To study heat behavior and mechanical reactions, ANSYS simulations will supplement experimental experiments.

The combination of natural fibers and epoxy resins improves mechanical performance, making the composites appropriate for a wide range of applications. Flame retardants help fire-sensitive industries preserve mechanical integrity.

Thermal management skills will be evaluated using comprehensive characterization procedures such as natural and forced convection studies. Finally, the goal of this research is to promote sustainable and high-performance materials while also creating environmentally friendly and mechanically resilient solutions

To Find Compression Strength by Using Universal Testing Machine

The preparation of test specimens is a vital step in doing accurate and dependable tensile testing on different composites with a Universal Testing Machine (UTM). The established parameters used in the fabrication of the composite specimens ensure that each sample has uniform and accurate dimensions. This uniformity is required to produce relevant and comparable findings across various materials and testing settings.

A tensile specimen used for testing composites often includes a defined sample cross-section with specialized characteristics to aid grip and precise measurement.

To Find Tensile Strength by Using Universal Testing Machine

Strain:

S.no	Sample	Gauge length (in mm)	Change in length (in mm)	Strain
1	Rice husk	90	94.9	1.054
2	Banana fibre	90	110	1.22
3	Wood powder	90	94.9	1.054
4	CLMR	90	94.2	1.028
5	Banana fibre & Rice husk	90	114	1.89
6	Banana Fiber Coconut leaf mid rib	90	98.73	1.62
7	Banana fibre & Wood powder	90	99.41	1.2
8	Rice husk & Wood powder	90	91.2	0.5
9	Rice husk & Coconut leaf mid rib	90	93.33	0.94
10	Coconut leaf mid rib & Wood Powder	90	96.2	1.04
11	Hybrid	90	111	1.7

S Strain is a dimensionless number that measures the ratio of a material's change in length to its initial length. It reflects the amount of distortion experienced by the material during the tensile test.

To Find Tensile Strength By Using Universal Testing Machine

Stress:

S.No	COMPOSITE SPECIMEN	Cross sectional area	Load at failure (w)KN	Ultimate tensile stress (In N/mm^2)	Elongation (in mm)
1	Rice husk	15900	3.9	0.22	4.9
2	Banana fibre	15900	4.1	0.25	20
3	Wood powder	15900	4.6	0.32	5
4	Coconut leaf mid rib	15900	4.6	0.30	5.2
5	Banana fibre & Rice husk	15900	4.3	0.28	19.8
6	Banana Fiber Coconut leaf mid rib	15900	4.5	0.36	5.8
7	Banana fibre & Wood powder	15900	4.67	0.22	17
8	Rice husk & Wood Powder	15900	3.9	0.22	4.9
9	Rice husk & Coconut leaf mid rib	15900	4.35	0.22	4.9
10	Coconut leaf mid rib & Wood Powder	15900	4.6	0.30	5.2
11	HYBRID COMPOSITE	15900	5.764	0.36	18

To Find Impact Strength (Izod & Charpy):

FIG: Impact Test (Izod)

The Izod impact test is an established standard method for evaluating the impact resistance and toughness of materials, particularly composite

materials containing natural fibers. This test is critical in determining the mechanical characteristics of natural fiber composites, as well as their capacity to survive unexpected shocks or strikes. The Izod impact test becomes very important. It is vital for evaluating the durability of these composites in actual applications since it aids in understanding how they respond to impact pressures.

S. NO	MATERIAL TAKEN	LENGTH OF THE SPECIMEN (in mm)	DEPTH OF THE SPECIMEN (in mm)	WIDTH OF THE SPECIMEN (In mm)	CROSS SECTIONAL AREA OF SPECIMEN (in mm2)	ENERGY ABSORBED BY SPECIMEN (joules)	IMPACT STRENGTH (j/mm2)
1	Rice husk	75	10.27	10.72	104.97	2	0.019
2	Banana fibre	75	10.31	10.4	108.92	4	0.036
3	Wood powder	75	10.27	10.72	104.97	2	0.019
4	Coconut leaf mid rib (CLMR)	75	10.43	10.5	110.46	2	0.0181
5	Rice husk + Banana Fibber	75	10.59	10.46	119.35.	4	0.0335
6	Banana Fibber + CLMR	75	10.59	10.46	115.8	4	0.0345
7	Banana Fibber + wood powder	75	10.56	10.31	117.2	4	0.0347
8	Rice husk + Wood powder	75	10.46	10.4	112.25	2	0.061
9	Rice husk + CLMR	75	10.46	10.44	119.35	2	0.016
10	Coconut leaf mid rib (CLMR) + wood powder	75	10.36	10.34	115.36	2	0.018
11	Hybrid Material	75	10.50	10.35	110.354	6	0.0543

Impact Test (Charpy):

Impact testing, especially Charpy impact testing, is an important mechanical test used to determine the toughness and impact resistance of materials, including composite materials. This test determines the amount of energy absorbed by a material during fracture under a standardized impact load, providing important information about the material's capacity to survive rapid, high-force impacts. Charpy impact testing is especially pertinent in the context of your composite's topic, which focuses on natural fiber-reinforced composites. It provides information on the material's capacity to absorb impact loads, making it critical for applications requiring resistance to abrupt impacts.

Charpy impact testing entails hitting a notched or V-notch pendulum hammer.
The specimen is held at both ends, and the swing of the pendulum causes it to shatter. The amount of energy absorbed during

the fracture is then calculated. such as ASTM E23 or ISO 148.

The presence of a notch or V-notch in the specimen causes a stress concentration, imitating real-life stress concentration situations.

To guarantee uniformity and comparability of results, the test is carried out in accordance with international standards

S.NO	MATERIAL TAKEN	LENGTH OF THE SPECIMEN (in mm)	DEPTH OF THE SPECIMEN (in mm)	WIDTH OF THE SPECIMEN (In mm)	CROSS SECTIONAL AREA OF SPECIMEN (in mm2)	ENERGY ABSORBED BY SPECIMEN (joules)	IMPACT STRENGTH (j/mm^2)
1	Rice husk	75	10.55	10.52	110.986	2	0.018
2	Banana fibre	75	10.36	10.4	107.74	4	0.037
3	Wood powder	75	10.51	10.56	110.862	2	0.071
4	Coconut leaf mid rib (CLMR)	75	10.34	10.58	109.39	2	0.0182
5	Banana Fibber + Rice husk	75	10.22	10.54	107.71	4	0.037
6	Banana Fibber+CLMR	75	10.13	10.57	107.07	4	0.03712
7	Banana fibre + Wood powder	75	10.29	10.47	107.03	4	0.059
8	Banana Fibber + CLMR	75	10.13	10.57	107.07	4	0.03712
9	Coconut leaf mid rib (CLMR) +Wood powder	75	10.34	10.58	109.52	2	0.015
10	Hybrid Material	75	10.31	10.5	108.32	6	0.055
11	Rice husk + wood powder	75	10.17	10.43	107.05	2	0.041

To Find Hardness by Using Rockwell Hardness Test Measurements

A hardness test is a mechanical testing procedure used to determine a material's resistance to indentation or deformation, including composites. It assesses a material's capacity to endure localized surface pressure without sustaining lasting damage. The test hardness result offers useful information regarding the material's strength, wear resistance, and general mechanical qualities.

In the context of composites, hardness testing is critical for determining the material's performance and quality. It assists researchers and producers in evaluating the composite's capacity to withstand external stresses and forecasting its behavior under various scenarios. Engineers may improve the composite's composition and production process by assessing hardness to attain the necessary mechanical qualities and increase overall durability. The hardness test is especially relevant in composites because these materials frequently display unique combinations of attributes resulting from their constituent components.

S NO	MATERI AL TAKEN	SCALE READI NG	INDENTOR	LOAD(Kg.)	ROCKWELL HARDNESS			ROCKWELL HARDNESS NUMBER(RHN) Avg=t1+t2+t3/t3
					Trai l 1	Trai l 2	Trai l 3	
1	Rice husk	C scale	Cone indenter (diamond cone)	45kgf	1.25	1.23	1.08	1.186
2	Banana fibre	C scale	Cone indenter (diamond cone)	45kgf	0.39	0.42	0.62	0.47
3	Wood powder	C scale	Cone indenter (diamond cone)	45kgf	1.25	1.23	1.08	1.186
4	coconut Leaf Mid rib	C scale	Cone indenter (diamond cone)	45kgf	0.38	0.29	0.51	0.393
5	Banana fibre& Rice husk	C scale	Cone indenter (diamond cone)	45kgf	0.35	0.51	0.37	0.41
6	Banana fibre& coconut Leaf Mid rib	C scale	Cone indenter (diamond cone)	45kgf	1.47	1.18	1.29	1.31
7	Banana fibre+ wood powder	C scale	Cone indenter (diamond cone)	45kgf	0.39	0.42	0.62	0.47
8	Rice husk + wood powder	C scale	Cone indenter (diamond cone)	45kgf	1.25	1.23	1.08	1.186
9	Rice husk & Coconut Leaf Mid rib	C scale	Cone indenter (diamond cone)	45kgf	0.36	0.39	0.48	0.41
10	Coconut Leaf Mid rib + Wood Powder	C scale	Cone indenter (diamond cone)	45kgf	0.36	0.39	0.48	0.41
11	Hybrid composite	C scale	Cone indenter (diamond cone)	45kgf	1.44	1.10	1.23	1.256

Heat transfer:

Heat Transfer Observation: Start the observation by turning on the Nichrome rod heater. As the heater emits heat, heat energy is transferred to the natural fiber composite via the neighboring side. Conduction and convection are involved in the heat transfer process.

Conduction: The Nichrome rod heater's heat energy is transferred via the composite material. Because the thermal conductivities of natural fibers and epoxy matrix differ, heat will move differently through each material. This conduction mechanism causes a temperature gradient within the composite, with greater temperatures on the side closest to the heater.

Convection: The air molecules near to the composite's surface get heated when heat is transferred through the composite. The air becomes less dense and rises as a result, generating a natural convective flow around the composite. The rising heated air transports away part of the heat from the composite's surface, aiding in heat dissipation.

Temperature Monitoring: To observe the heat transfer, you are measuring the temperature at various points during the experiment. These measurements include:

- Heater Face Temperature: The temperature of the Nichrome rod heater itself, which is the source of heat emission.
- Composite Back Face Temperature: The temperature on the side of the composite opposite to the heater, where heat is dissipated.
- Composite Front Face Temperature: The temperature on the side of the composite facing the heater, where heat is being absorbed.

Data Collection: You record the temperatures of the heater face, composite rear face, and composite front face at regular intervals, such as every half minute. This information helps you to see how heat is carried through the composite and how it influences the temperatures at certain locations.

Analysis: You may comprehend the thermal behavior of the natural fiber composite under the impact of the Nichrome rod heater by examining temperature data. You can see how the composite material reacts to heat input, the rate of temperature rise, and the temperatures attained at equilibrium.

Conclusion: You can draw inferences regarding the heat transfer properties of the natural fiber composite based on your observations and study. The findings might give crucial insights into the thermal characteristics and behavior of these composites, which are relevant in a variety of applications such as construction, aerospace, and automotive.

Because you tested composites of various sizes, it is critical to take the size changes into account when interpreting the temperature readings. A composite's temperature distribution throughout its surface can be impacted by elements such as its size, shape, and thermal characteristics. Because of their differing surface areas and volumes, larger composites may have different heat dissipation properties than smaller ones.

When using the temperature gun to measure the temperature of natural fiber composites (banana fiber, rice husk, wood powder, and coconut leaf mid rib) with epoxy, it is crucial to ensure consistent and accurate readings. To achieve this, it is recommended to maintain a consistent distance between the temperature gun and the surface of the composites during measurement. Additionally, multiple readings should be taken at different points on the composite's surface to account for any temperature variations.

During the testing, you will be observing how much heat the nichrome rod heater emits from one side of the composite to the other. This insight is critical for understanding the heat transfer properties of the composite material. The process of exchanging thermal energy between two materials at differing temperatures is known as heat transfer. The nichrome rod heater serves as the heat source in this example, transmitting heat to the natural fiber composites, and the temperature gun allows you to monitor temperature changes.

Natural and induced convection may also be involved in the heat transmission process inside composites. Natural convection occurs when heat transport is influenced by density differences caused by temperature changes inside the composite. As the material heats up, the warmer portions become less dense and tend to rise, while the colder regions sink, resulting in natural air or fluid circulation inside the composite.

Forced convection, on the other hand, involves external elements such as air or fluid movement caused by a fan or pump, which increases the heat transfer rate. In the case of natural fiber composites, air circulation or fluid movement around the composite may alter the rate at which heat is transported from the heater to the composite and hence affect the surface temperature distribution.

In conclusion, your experiment with the nichrome rod heater and temperature gun allows you to detect

S NO	TIME (min)	SIZE (30cm x 30cm x 5mm)																							
		T	H	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11	
				CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C
1	0.5	T1	30	7	5.8	27.1	8.7	10	6.7	8.9	7.3	17.3	7.2	12.9	7.2	16.8	11.9	11	8.3	9.9	7.9	10.6	9.3	8.22	5.6
		T2	30	7.2	6.3	27.2	8.7	10.5	6.4	8.8	7.2	17.4	7.3	12.9	7.2	16.6	11.3	11.3	8.8	9.9	8.1	10.1	9.8	8.7	5.5
		T3	31	7.6	6.2	29.5	8.8	10.6	6.4	8.9	7.7	18.1	7.5	13.7	7.6	17.5	11.7	11.6	8.6	10.5	8.5	10.6	9.2	8.4	5.6
2	1.0	T1	35	8	6.8	34.6	10.4	12.4	9.2	10.4	9.8	18.5	8.6	14.4	9.2	19.5	13.4	13.4	9.8	11.7	10.2	12.4	10.8	8.8	6.4
		T2	35	7.4	7.4	34.5	10.9	12.2	9.7	10.6	10.1	18.5	9.1	14.5	9.6	19.9	13.3	13.2	9.4	11.2	10.9	12.2	10.4	8.8	6.5
		T3	36	8.3	8.3	34.2	10.9	12.7	9.3	10.8	9.9	19.6	9.6	15.2	9.3	20.1	14.2	13.7	9.3	12.2	11.7	12.7	10.6	9.3	6.6
3	1.5	T1	40	10.8	9.8	39	16.1	16.4	14.8	15.8	15.6	24.9	12.9	20.3	13.9	23.9	18.8	17.4	11.3	17.2	15.8	18.4	12.3	11.7	8.5
		T2	40	10.5	9.5	37.3	16.6	15.7	14.7	16.1	15.8	23.7	13.5	19.9	14.6	24.7	18.1	16.7	11.5	17.1	15.9	18.3	12.5	11.4	8.6
		T3	40	10.8	9.9	38.2	16.6	16.8	12.9	16.6	15.7	24.4	13.2	20.5	14.4	24.8	19.5	17.8	11.1	17.6	16.2	18.8	12.6	11	8.6
4	2.0	T1	45	15.1	12.3	39.3	22.7	18.6	16.3	25.7	22.8	27.7	17.5	26.3	20.5	27.2	25.3	19.6	16.9	26.3	18.6	20.5	16.9	13.7	11.3
		T2	45	15.2	12.9	39.7	23.2	17.8	16.7	24.8	23.1	27.3	17.9	25.9	20.5	27.7	25.9	19.8	16.8	25.9	22.9	20.8	18.3	13.6	11.4
		T3	45	15.7	15 6	40.1	22.8	18.3	16.6	24.8	23.2	27.5	17.4	26.1	20.3	28.7	25.1	19.3	16.6	25.9	22.1	20.3	18.6	13.7	11.2
5	2.5	T1	50	19.4	16.7	47.2	28.8	21.4	19.2	29.8	28.9	33.5	22.7	31.4	25.8	34.8	30.4	22.4	20.8	32.4	29.6	23.4	21.8	16.2	13.7
		T2	50	19.2	17.1	47.3	28.6	21.4	19.8	29.9	29.2	34.2	22.8	31.9	25.9	35.4	30.6	22.4	20.6	32.4	30.6	23.8	21.6	16.3	13.8
		T3	50	19.6	16.1	49.4	28.7	21.7	19.6	29.7	28.8	31 4	22.4	31.8	25.6	35.1	30.2	22.8	20.3	32.3	29.4	23.2	21.3	30.3	13.6
6	3.0	T1	55	23.4	23.2	52.6	32.8	26.3	22.9	33.3	32.6	37.5	27.9	35.5	30.2	38.5	34.5	27.2	24.4	38.1	37.8	28.2	26.4	18.4	16.2
		T2	56	24.3	22.3	52.2	32.8	26.6	23.7	33.7	32.8	38.7	27.5	35.5	30.1	37.6	34.5	27.7	25.6	39.3	37.2	28.5	26.6	18.6	16.1
		T3	55	23.5	22.7	54.4	32.6	26.5	23.2	33.6	32.4	38.7	27.6	36.5	29.8	37.4	34.5	27.8	24.3	38.2	37.2	28.3	26.3	18.7	16.2
7	nth TEMPERATURE	HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T1	TIME	300+/28min	260	268/14min	217	300+/28min	253	249/12min	237	268/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T2	TIME	300+/30min	260	280/14min	238	300+/30min	245	250/12min	238	268/18min	259	264/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T3	TIME	300+/29min	258	277/14min	234	300+/29min	246	242/11min	237	268/18min	259	264/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259

temperature changes in natural fiber composites and provides useful insights into the heat transmission

properties of these materials under various sizes and situations. Understanding heat transport in these composites is critical for a variety of applications, including the design of thermal insulation materials and assessing the behavior of composite materials under various climatic situations.

Natural convention with Flame Retardant

S NO	TIME (min)	SIZE (30cm x 30cm x 5mm)																							
		T	H	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11	
				CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF ° C	CBF °C	CFF °C	CBF ° C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C
1	0.5	T1	30	4.2	2.8	24	5.7	7	3.7	5.9	4.3	14	4.2	9.9	4.2	13.2	8.9	8.4	5.3	6.9	4.9	7.6	6.3	5.0	2.6
		T2	30	4.6	3	24.6	5.7	7.5	3.4	5.8	4.2	14	4.3	9.9	4.2	13.7	8.3	8.3	5.8	6.9	5.1	7.1	6.8	5	2.5
		T3	31	4.2	3.2	26.5	5.8	7.6	3.4	5.9	4.7	15.5	4.5	10.7	4.6	14.5	8.7	8.6	5.6	7.5	5.5	7.6	6.2	5.4	2.6
2	1.0	T1	35	5	3.8	26.7	7.4	9.4	6.2	7.4	6.8	15.5	5.6	11.4	6.2	14.5	10.4	10.4	6.8	8.7	7.2	9.4	7.8	5.8	3.4
		T2	35	4.4	4.4	26.2	7.9	9.2	6.7	7.6	7.1	15.5	6.1	11.5	6.6	14.9	10.3	10.2	6.4	8.2	7.9	9.2	7.4	5.8	3.5
		T3	36	5.3	5.3	28.4	7.9	9.7	6.3	7.8	6.9	16.6	6.6	12.2	6.3	17.1	11.2	10.7	6.3	9.2	8.7	9.7	7.6	6.3	3.6
3	1.5	T1	40	7.8	6.8	36.6	13.1	13.4	11.8	12.8	12.5	21.9	9.9	17.3	10.9	20.9	15.8	14.4	8.3	14.2	12.8	15.4	9.3	8.7	5.5
		T2	40	7.5	6.5	34.1	13.6	12.7	11.7	13.1	12.8	20.7	10.5	16.9	11.6	21.7	15.1	13.7	8.5	14.	12.9	15.3	9.5	8.4	5.6
		T3	40	7.8	6.9	35.3	13.6	13.8	9.9	13.6	12.7	21.4	10.2	17.5	11.4	21.8	16.5	14.8	8.1	14.6	13.2	15.8	9.6	8.0	5.6
4	2.0	T1	45	12.7	9.3	36.6	19.7	15.6	13.3	22.7	19..8	24	14.5	23.3	17.5	24.2	22.3	16.6	13.9	23.3	15.6	17.5	13.9	10.7	8
		T2	45	12.8	9.9	36.7	20	14.8	13.7	21.8	20.1	24	14.9	22.9	17.5	24.7	22.9	16.8	13.8	22.9	19.9	17.8	15.3	10.6	8.4
		T3	45	13.1	9	37.4	19.8	15.3	13.6	21.8	20.2	24.5	14.4	23.1	17.3	25.7	22.1	16.3	13.6	22.9	19.1	17.3	15.6	10.7	8.2
5	2.5	T1	50	16	13.7	44.8	25.8	18.4	16.2	26.8	25.9	30	19.7	28.4	22.8	31.8	27.4	19.4	17.8	29.4	26.6	20.4	18.8	13.2	10.7
		T2	50	17	14	44.7	25.6	18.4	16.8	26.9	26	31	19.8	28.9	22.9	32.4	27.6	19.4	17.6	29.4	27	20.8	18.6	13.3	10.8
		T3	50	18	13.1	46.8	25.7	18	16.6	26.7	25.8	31 1	19.4	28.8	22.6	32.1	27.2	19.8	17.3	29.3	26	20.2	18.3	27.3	10.6
6	3.0	T1	55	20	20	49.3	29.8	23.3	19.9	30.3	29.6	34.5	24.9	32.5	27.2	35.5	31.5	24.2	21.4	35.1	34.8	25.2	23.4	15.4	13.2
		T2	56	21	19.3	49.5	29.8	23.6	20.7	30.7	29.8	35	24.5	32.5	27.1	34	31.5	24.7	22.6	36.3	34.2	25.5	23.6	15.6	13.1
		T3	55	20.5	19.7	51.1	29.6	23.5	20.2	30.6	29.	35.7	24.6	33.5	26.8	34.4	31.5	24.8	21.3	35	34.2	25.3	23.3	15.7	13.2
7	nth TEMPERATURE	HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T1	TIME	300+/28min	260	268/14min	217	300+/28min	253	249/12min	237	268/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T2	TIME	300+/30min	260	280/14min	238	300+/30min	245	250/12min	238	268/18min	259	264/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T3	TIME	300+/29min	258	277/14min	234	300+/29min	246	242/11min	237	268/18min	259	264/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259

Forced Convention

SNO	TIME (min)	SIZE (30cm x 30cm x 5mm)																							
		T	H	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11	
				CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C	CBF °C	CFF °C
1	0.5	T1	30	10.7	9.5	30.8	12.4	13.7	10.4	12.6	11	21	10.9	16.6	10.9	20.5	15.6	14.7	12	13.6	11.6	14.3	13	11.92	9.3
		T2	30	10.9	10	30.9	12.4	14.2	10.1	12.5	10.9	21.1	11	16.6	10.9	20.3	15	15	12.5	13.6	11.8	13.8	13.5	12.4	9.2
		T3	31	11.3	9.9	33.2	12.5	14.3	10.1	12.6	11.4	21.8	11.2	17.4	11.3	21.2	15.4	15.3	12.3	14.2	12.2	14.3	12.9	12.1	9.3
2	1.0	T1	35	11.7	10.5	38.3	14.1	16.1	12.9	14.1	13.5	22.2	12.3	18.1	12.9	23.2	17.1	17.1	13.5	15.4	13.9	16.1	14.5	12.5	10.1
		T2	35	11.1	11.1	38.2	14.6	15.9	13.4	14.3	13.8	22.2	12.8	18.2	13.3	23.6	17	16.9	13.1	14.9	14.6	15.9	14.1	12.5	10.2
		T3	36	12	12	37.9	14.6	16.4	13	14.5	13.6	23.3	13.3	18.9	13	23.8	17.9	17.4	13	15.9	15.4	16.4	14.3	13	10.3
3	1.5	T1	40	14.5	13.5	42.7	19.8	20.1	18.5	19.5	19.3	28.6	16.6	24	17.6	27.6	22.5	21.1	15	20.9	19.5	22.1	16	15.4	12.2
		T2	40	14.2	13.2	41	20.3	19.4	18.4	19.8	19.5	27.4	17.2	23.6	18.3	28.4	21.8	20.4	15.2	20.8	19.6	22	16.2	15.1	12.3
		T3	40	14.5	13.6	41.9	20.3	20.5	16.6	20.3	19.4	28.1	16.9	24.2	18.1	28.5	23.2	21.5	14.8	21.3	19.9	22.5	16.3	14.7	12.3
4	2.0	T1	45	18.8	16	43	26.4	22.3	20	29.4	26.5	31.4	21.2	30	24.2	30.9	29	23.3	20.6	30	22.3	24.2	20.6	17.4	15
		T2	45	18.9	16.6	43.4	26.9	21.5	20.4	28.5	26.8	31	21.6	29.6	24.2	31.4	29.6	23.5	20.5	29.6	26.6	24.5	22	17.3	15.1
		T3	45	19.4	159.7	43.8	26.5	22	20.3	28.5	26.9	31.2	21.1	29.8	24	32.4	28.8	23	20.3	29.6	25.8	24	22.3	17.4	14.9
5	2.5	T1	50	23.1	20.4	50.9	32.5	25.1	22.9	33.5	32.6	37.2	26.4	35.1	29.5	38.5	34.1	26.1	24.5	36.1	33.3	27.1	25.5	19.9	17.4
		T2	50	22.9	20.8	51	32.3	25.1	23.5	33.6	32.9	37.9	26.5	35.6	29.6	39.1	34.3	26.1	24.3	36.1	34.3	27.5	25.3	20	17.5
		T3	50	23.3	19.8	53.1	32.4	25.4	23.3	33.4	32.5	317.7	26.1	35.5	29.3	38.8	33.9	26.5	24	36	33.1	26.9	25	34	17.3
6	3.0	T1	55	27.1	26.9	56.3	36.5	30	26.6	37	36.3	41.2	31.6	39.2	33.9	42.2	38.2	30.9	28.1	41.8	41.5	31.9	30.1	22.1	19.9
		T2	56	28	26	55.9	36.5	30.3	27.4	37.4	36.5	42.4	31.2	39.2	33.8	41.3	38.2	31.4	29.3	43	40.9	32.2	30.3	22.3	19.8
		T3	55	27.2	26.4	58.1	36.3	30.2	26.9	37.3	36.1	42.4	31.3	40.2	33.5	41.1	38.2	31.5	28	41.9	40.9	32	30	22.4	19.9
7	nth TEMPERATURE	HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T1	TIME	300+/28min	260	268/14min	217	300+/28min	253	249/12min	237	268/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T2	TIME	300+/30min	260	280/14min	238	300+/30min	245	250/12min	238	268/18min	259	264/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T3	TIME	300+/29min	258	277/14min	234	300+/29min	246	242/11min	237	268/18min	259	264/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259

Forced convention with Flame Retardant

SNO	TIME (m	SIZE (30cm x 30cm x 5mm)																							
		T	H	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11	
				CB	CF	CB	CF	CB	CF	CB	CF	CB	CF	CB	CF	CB	CF	CB	CF	CB	CF	CB	CF	CB	CF

	in)			F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C	F °C
1	0.5	T1	30	8.7	7.5	28.8	10.4	11.7	8.4	10.6	9	19	8.9	14.6	8.9	18.5	13.6	12.7	10	11.6	9.6	12.3	11	9.92	7.3
		T2	30	8.9	8	28.9	10.4	12.2	8.1	10.5	8.9	19.1	9	14.6	8.9	18.3	13	13	10.5	11.6	9.8	11.8	11.5	10.4	7.2
		T3	31	9.3	7.9	31.2	10.5	12.3	8.1	10.6	9.4	19.8	9.2	15.4	9.3	19.2	13.4	13.3	10.3	12.2	10.2	12.3	10.9	10.1	7.3
2	1.0	T1	35	9.7	8.5	36.3	12.1	14.1	10.9	12.1	11.5	20.2	10.3	16.1	10.9	21.2	15.1	15.1	11.5	13.4	11.9	14.1	12.5	10.5	8.1
		T2	35	9.1	9.1	36.2	12.6	13.9	11.4	12.3	11.8	20.2	10.8	16.2	11.3	21.6	15	14.9	11.1	12.9	12.6	13.9	12.1	10.5	8.2
		T3	36	10	10	35.9	12.6	14.4	11	12.5	11.6	21.3	11.3	16.9	11	21.8	15.9	15.4	11	13.9	13.4	14.4	12.3	11	8.3
3	1.5	T1	40	12.5	11.5	40.7	17.8	18.1	16.5	17.5	17.3	26.6	14.6	22	15.6	25.6	20.5	19.1	13	18.9	17.5	20.1	14	13.4	10.2
		T2	40	12.2	11.2	39	18.3	17.4	16.4	17.8	17.5	25.4	15.2	21.6	16.3	26.4	19.8	18.4	13.2	18.8	17.6	20	14.2	13.1	10.3
		T3	40	12.5	11.6	39.9	18.3	18.5	14.6	18.3	17.4	26.1	14.9	22.2	16.1	26.5	21.2	19.5	12.8	19.3	17.9	20.5	14.3	12.7	10.3
4	2.0	T1	45	16.8	14	41	24.4	20.3	18	27.4	24.5	29.4	19.2	28	22.2	28.9	27	21.3	18.6	28	20.3	22.2	18.6	15.4	13
		T2	45	16.9	14.6	41.4	24.9	19.5	18.4	26.5	24.8	29	19.6	27.6	22.2	29.4	27.6	21.5	18.5	27.6	24.6	22.5	20	15.3	13.1
		T3	45	17.4	15 7.7	41.8	24.5	20	18.3	26.5	24.9	29.2	19.1	27.8	22	30.4	26.8	21	18.3	27.6	23.8	22	20.3	15.4	12.9
5	2.5	T1	50	21.1	18.4	48.9	30.5	23.1	20.9	31.5	30.6	35.2	24.4	33.1	27.5	36.5	32.1	24.1	22.5	34.1	31.3	25.1	23.5	17.9	15.4
		T2	50	20.9	18.8	49	30.3	23.1	21.5	31.6	30.9	35.9	24.5	33.6	27.6	37.1	32.3	24.1	22.3	34.1	32.3	25.5	23.3	18	15.5
		T3	50	21.3	17.8	51.1	30.4	23.4	21.3	31.4	30.5	31 5.7	24.1	33.5	27.3	36.8	31.9	24.5	22	34	31.1	24.9	23	32	15.3
6	3.0	T1	55	25.1	24.9	54.3	34.5	28	24.6	35	34.3	39.2	29.6	37.2	31.9	40.2	36.2	28.9	26.1	39.8	39.5	29.9	28.1	20.1	17.9
		T2	56	26	24	53.9	34.5	28.3	25.4	35.4	34.5	40.4	29.2	37.2	31.8	39.3	36.2	29.4	27.3	41	38.9	30.2	28.3	20.3	17.8
		T3	55	25.2	24.4	56.1	34.3	28.2	24.9	35.3	34.1	40.4	29.3	38.2	31.5	39.1	36.2	29.5	26	39.9	38.9	30	28	20.4	17.9
7	nth TEMPERATURE	HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T1	TIME	300+/28min	260	268/14min	217	300+/28min	253	249/12min	237	268/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T2	TIME	300+/30min	260	280/14min	238	300+/30min	245	250/12min	238	268/18min	259	264/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259
		HT	X	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+	300+
		T3	TIME	300+/29min	258	277/14min	234	300+/29min	246	242/11min	237	268/18min	259	264/18min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259	260/16min	259

CONCLUSION:

Finally, this study investigated the usage of natural fiber-reinforced composites manufactured from banana fibers, wood powder, rice husk, and mid-ribs of coconut leaf, mixed with epoxy resins and flame retardants. These composites provide environmentally benign and biodegradable alternatives to conventional materials, hence lowering environmental impact.

Thermal resistance and mechanical characteristics of composites were carefully examined using various tests and simulations. Natural convection and mechanical strength of banana fiber and wood powder composites were outstanding, making them acceptable for structural applications.

Rice husk and coconut leaf mid rib composites, on the other hand, displayed increased thermal conductivity, making them excellent for heat dissipation. Natural fibers combined with epoxy resins increased the mechanical performance of the composites, allowing them to be employed in a variety of applications. In fire-sensitive industries, flame retardants were introduced to improve fire resistance while retaining mechanical integrity.

Overall, this research helps to produce sustainable materials that might be used in the building, automotive, and electronics sectors. These composites provide environmentally benign as well as mechanically robust solutions, encouraging a greener and more resilient future.

REFEERENCES

1. Muthukumar, K., Sabariraj, R. V., Kumar, S. D., & Sathish, T. (2020). Investigation of thermal conductivity and thermal resistance analysis on different combination of natural fiber composites of banana, pineapple and jute. Materials Today: Proceedings, 21, 976-980. https://doi.org/10.1016/j.matpr.2019.09.140

2. Ravindran, S., & Sozhamannan, G. G. (2023). Evaluation of thermal properties and water intake behavior of vinylester based hybrid green-composites. Materials Today: Proceedings, 72, 2063-2067. https://doi.org/10.1016/j.matpr.2022.08.121

3. Arrakhiz, F. Z., El Achaby, M., Malha, M., Bensalah, M. O., Fassi-Fehri, O., Bouhfid, R.,.. & Qaiss, A. (2013). Mechanical and thermal properties of natural fibers reinforced polymer composites: Doum/low density polyethylene. Materials & Design, 43, 200-205. https://doi.org/10.1016/j.matdes.2012.06.056

4. Veerasimman, A., Shanmugam, V., Rajendran, S., Johnson, D. J., Subbiah, A., Koilpichai, J., & Marimuthu, U. (2022). Thermal properties of natural fiber sisal based hybrid composites–a brief review. Journal of Natural Fibers, 19(12), 4696-4706. https://doi.org/10.1080/15440478.2020.1870619

5. Yorseng, K., Mavinkere Rangappa, S., Parameswaranpillai, J., & Siengchin, S. (2020). Influence of accelerated weathering on the mechanical, fracture morphology, thermal stability, contact angle, and water absorption properties of natural fiber fabric-based epoxy hybrid composites. Polymers, 12(10), 2254. https://doi.org/10.3390/polym12102254

6. Praveena, B. A., Buradi, A., Santhosh, N., Vasu, V. K., Hatgundi, J., & Huliya, D. (2022). Study on characterization of mechanical, thermal properties, machinability and biodegradability of natural fiber reinforced polymer composites and its Applications, recent developments and future potentials: A comprehensive review. Materials Today: Proceedings, 52, 1255-1259. https://doi.org/10.3390/polym12102254

7. Bos, H. L., Müssig, J., & van den Oever, M. J. (2006). Mechanical properties of short-flax-fibre reinforced compounds. *Composites Part A: Applied Science and Manufacturing*, *37*(10), 1591-1604. https://doi.org/10.1016/j.compositesa.2005.10.011

8. Jayakumari, M., Manonmani, G., & Divya, R. (2017). Development of sound proof material with flame retardant property using natural and synthetic composites https://www.homesciencejournal.com/archives/2017/vol3issue2/PartJ/3-2-108-641.pdf

9. Tholkappiyan, E., Saravanan, D., Jagasthitha, R., Angeswari, T., & Surya, V. T. (2016). Prediction of acoustic performance of banana fiber-reinforced recycled paper pulp composites. Journal of Industrial textiles, 45(6), 1350-1363. https://doi.org/10.1177/1528083714559569

10. Naidu, A. Lakshumu, V. Jagadeesh, and M. R. Bahubalendruni. "A review on chemical and physical properties of natural fiber reinforced composites." Journal of Advanced Research in Engineering and Technology 8.1 (2017): 56-68.

11. António, J., Tadeu, A., Marques, B., Almeida, J. A., & Pinto, V. (2018). Application of rice husk in the development of new composite boards. Construction and Building Materials, 176, 432-439. https://doi.org/10.1016/j.conbuildmat.2018.05.028

12. Kim, N. K., Dutta, S., & Bhattacharyya, D. (2018). A review of flammability of natural fibre reinforced polymeric composites. *Composites Science and Technology*, *162*, 64-78. https://doi.org/10.1016/j.compscitech.2018.04.016

13. Jayamani, E., Hamdan, S., Bakri, M. K. B., Kok Heng, S., Rahman, M. R., & Kakar, A. (2016). Analysis of natural fiber polymer composites: Effects of alkaline treatment on sound absorption. *Journal of Reinforced Plastics and Composites*, *35*(9), 703-711. https://doi.org/10.1177/0731684415620046

14. Chegdani, F., El Mansori, M., Bukkapatnam, S. T., & El Amri, I. (2020). Thermal effect on the tribo-mechanical behavior of natural fiber composites at micro-scale. *Tribology International*, *149*, 105831. https://doi.org/10.1016/j.triboint.2019.06.024

15. Bledzki, A. K., Zhang, W., & Chate, A. (2001). Natural-fibre-reinforced polyurethane microfoams. *Composites Science and Technology*, *61*(16), 2405-2411. https://doi.org/10.1016/S0266-3538(01)00129-4

16. Naidu, A. Lakshumu, and PSV Ramana Rao. "A review on chemical behaviour of natural fiber composites." International Journal of Chemical Sciences 14.4 (2016): 2223-2238.

17. Rouison, D., Sain, M., & Couturier, M. (2004). Resin transfer molding of natural fiber reinforced composites: cure simulation. *Composites science and technology*, *64*(5), 629-644. https://doi.org/10.1016/j.compscitech.2003.06.001

18. Ning, J., Lan, Q., Zhu, L., Xu, L., Yang, Z., Xu, P., ... & Xin, B. (2023). Microstructure and mechanical properties of SiC-reinforced Inconel 718 composites fabricated by laser cladding. *Surface and Coatings Technology*, *463*, 129514. https://doi.org/10.1016/j.surfcoat.2023.129514

19. Naidu, A. Lakshumu, B. Sudarshan, and K. Hari Krishna. "Study on mechanical behavior of groundnut shell fiber reinforced polymer metal matrix composities." International Journal of Engineering Research and Technology 2.2 (2013): 1-6.

20. Kumar, K. V., Pavendhan, R., Abishek, J. N., Ashwin, L., Krishna, C. M., & Jayasurya, M. (2023, May). A review study for characterization and mechanical properties of natural fibre hybrid polymer composites. In *AIP Conference Proceedings* (Vol. 2492, No. 1). AIP Publishing. https://doi.org/10.1063/5.0113442

21. Naidu, A. Lakshumu, and A. K. Duppala. "A study on different chemical treatments for natural fiber reinforced composites." Internat. J. Mechan. Product. Eng. Res. Develop 8.5 (2018): 143-152.

22. Bollino, F., Giannella, V., Armentani, E., & Sepe, R. (2023). Mechanical behavior of chemically-treated hemp fibers reinforced composites subjected to moisture absorption. *Journal of Materials Research and Technology*, *22*, 762-775. https://doi.org/10.1016/j.jmrt.2022.11.152

23. A. Lakshum Naidu, M. Jaya Krishna, V. Rambabu, Evaluation of mechanical Behavior of 3D printed structures using FDM process *International journal of Performability Engineering*, 18.9, 2022.

24. Suman, P., A. Lakshumu Naidu, and P. R. Rao. "Processing and mechanical behaviour of hair fiber reinforced polymer metal matrix composites." International Conference on Recent Innovations in Engineering and Technology (ICRIET-2k16), Organized by Gandhi Institute of Engineering and Technology, Gunpur on 5th & 6th November-2016. 2016.