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Thermal Performance and Study of Banana-Flax Fiber Reinforced with Rice Husk

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Abstract:

These investigations are about natural materials for thermal applications, which not only provide thermal performance but also adhere to sustainable and environmentally friendly principles, and have recently gained increased interest. To potentially address these needs, the creation of natural fiber compound bars is being investigated by this project. Carefully chosen binding agents are mixed with natural fibers known for their inherent strength and lightweight qualities to create a composite material with improved mechanical properties. Through methodical experimentation and analysis, this study aims to establish the viability of using natural fibers in mechanical engineering applications, thereby promoting a more resilient and sustainable future. Additionally, the paper discusses the utilization of natural fibers in the building industry, highlighting their excellent physical and mechanical properties and their potential for developing composite materials for various building applications.

Keywords: *- Banana fiber Mat, flex fiber Mat, Rice husk, Resin, and Hardener.*

1. Introduction:

The selection of materials utilized in composite fibers holds significant importance in defining the properties and potential applications of these sophisticated materials.Work focused on natural fibers for polymer composites.[1].Investigates natural fiber composite materials for high-performance applications[4].Composite fibers are commonly fabricated by amalgamating two or more dissimilar materials, resulting in a unified structure that exhibits enhanced performance attributes. Presented below is a comprehensive outline detailing the materials employed in the production of composite fibers. Natural fiber reinforced composites are being analysed for structural applications. Plant fibers are a better replacement for synthetic fibers in terms of cost and CO2 emissions [12]. Improved mechanical properties of composites with different weight ratios. Experimental investigation on composites with different weight ratios conducted[1].Composites are used in aerospace, shipbuilding, automobile, and wind turbine blade manufacturing . Natural fibre composites can be used in sports applications [12]. Natural-fiber sound dampening characteristics. Foamed products for upholsteries and insulation applications. Non-structural components in automotive applications [10]. Industries such as construction, building, packing, consumer goods, and military use natural fibres. Natural fibres are used in transportation applications like cars, trains, and aircraft [9].Applications for natural composites are found in packaging**,** furniture**,** and housing**,** as well as in the automotive**,** aviation, and shipping sectors[11].

2. Materials

2.1 Banana Fiber Mat

Banana fibers, extracted from the abundant pseudo-stems of banana plants and primarily consisting of cellulose, hemicellulose, and lignin, are emerging as a promising contender in the realm of sustainable construction materials. By undergoing water retting, treatment, and embedding in resins like epoxy or polyester, these fibers can be transformed into composite bars that offer a compelling alternative to traditional steel reinforcements. Moreover, their improved thermal and acoustic insulation properties make them particularly advantageous for non-load-bearingapplications such as beams, slabs, and fencing..Although initial tests show promise, further research is necessary tofully explore the potential of banana fiber composites in construction. It is worth highlighting that the ready availability and renewable nature of banana fibers contribute to minimizing waste and reducing dependence on resource-intensive steel production, aligning with the increasing demand for sustainable construction practices. As research progresses and production methods advance, banana fiber composite bars have the potential to revolutionizethe construction industry by offering a greener and more innovative alternative for building a sustainable future. While exploring applications beyond construction, such as in the automotive and aerospace sectors, is important, this analysis primarily focuses on the potential of banana fiber composites in sustainable construction applications.

Fig 1. Banana Fiber Mat

2.1 Flax Fiber Mat

Flax, renowned for its exquisite linen fabrics, is expanding its horizons into the construction sector with the introduction of eco-friendly composite bars. These bars, created by incorporating mats of short flax fibers into a resin such as epoxy, present themselves as unexpected contenders against traditional steel reinforcements. The process commences with the extraction and treatment of the fibers, enhancing their strength and compatibility with the resin.Once integrated, the resulting bars possess remarkable attributes - they are lightweight, highly resistant to corrosion, and exhibit tensile strength comparable to steel. Moreover, their thermal and acoustic insulation properties surpass those of steel, rendering them appealing for sustainable building applications. Additionally, the renewable nature of flax makes it an environmentally conscious choice, reducing dependence on resource-intensive steel production and minimizing agricultural waste. As research advances and production methods refine, flax fiber composite bars have the potential to revolutionize the construction industry, providing a green and innovative alternative for constructing a more sustainable future.

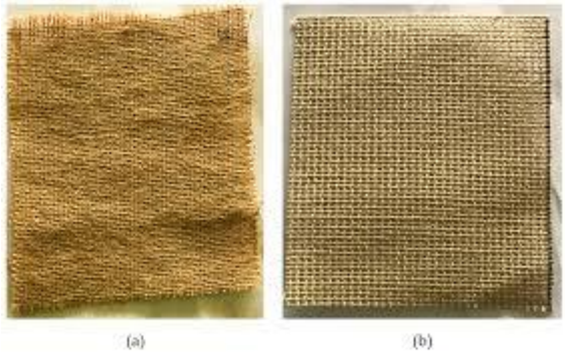

Fig 2. Flax Fiber Mat

2.2 Rice Husk Powder

Rice husk powder (RHP) is an agricultural byproduct that shows great promise as a reinforcement material for composite bars in sustainable construction. Derived from rice husks abundant in silica, RHP is combined with polymer matrices such as epoxy or polyester to create lightweight and environmentally friendly bars. These bars possessremarkable properties, including high tensile strength and enhanced fire resistance, thanks to the inherent fireretardancy of RHP. Although ongoing research is being conducted, initial studies indicate that RHP has potentialapplications in non-load-bearing structures like beams, slabs, and fencing. Importantly, the utilization of RHP helps reduce construction waste and decreases reliance on resource-intensive steel production, thereby contributing to amore sustainable future. It is imperative to further explore the use of RHP-reinforced composite bars, particularly inoptimizing mechanical performance and cost-effectiveness, to facilitate their wider adoption in the constructionindustry.

Fig 3. Rice Husk Powder

2.3 Epoxy Resin and Hardener

Araldite – Standard Hardner HV 953 epoxy resin (Araldite AW 106) are commonly used to strengthen natural fiberssuch as bananas and flax because of their exceptional mechanical properties, adhesion characteristics, and moisture resistance. Araldite – Standard Hardner HV 953 epoxy resin (Araldite AW 106) are commonly used to strengthen natural fiberssuch as bananas and flax because of their exceptional mechanical properties, adhesion characteristics, and moisture resistance.

This reinforcement process improves the inherent qualities of natural fibers, resulting in composites that have enhanced strength, stiffness, and dimensional stability. The epoxy resin acts as a matrix, enclosing the fibers and effectively distributing applied stresses. However, it is crucial to carefully select and modify the resin system to achieve optimal performance. Factors such as viscosity, flexibility, and compatibility with the fiber surface chemistryplay a significant role in the adhesion and transfer of stress between the fiber and matrix. Epoxy-reinforced natural fiber composites provide a sustainable alternative to conventional materials due to their biodegradability, low energy consumption during processing, and potential for utilizing recycled fibers. With continuous research and development, these environmentally friendly composites hold great promise for a wide range of applications in the automotive, construction, and aerospace industries.

Fig 4 Epoxy Resin and Hardner

2.4 Hand lay-up Method

The hand lay-up technique presents a straightforward and versatile approach to manufacturing composites that are reinforced with natural fibers. This method involves the manual placement of fiber mats or woven fabrics onto a Mold, followed by the infusion of a liquid resin system. Additional layers are carefully laid to ensure proper fiber orientationand overlap, resulting in the desired strength and thickness. The resin then undergoes a curing process, either at roomtemperature or with the application of heat and pressure, which effectively bonds the fibers together to create the finalcomposite product. The key advantages of this method include its cost-effectiveness, ability to accommodate complexshapes, and suitability for small-scale production. However, it is important to acknowledge certain limitations such as the potential for human errors, inconsistent distribution of the resin, and the possibility of air voids. These factors necessitate the involvement of skilled operators and the implementation of quality control measures

2.5 Compositions

No of Composites Bars:-3’no

- 210g (Resin+Hardner+3g Rice Husk)
- 215g (Resin+Hardner)
- 220g (Resin+Hardner+5g Rice Husk)

Note:- Adding with each ratio of Resin+Hardner “5grams” to the composites.

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S.No	Fibers No of layers(X)	Fibers Weight in grams(A)	Rice Husk in grams	Ratio	Resin &Hardenerin grams (B)=2*A
Specimen 1	10	105	3	1:2	140.33+70.33=210
Specimen 2	10	105	0	1:2	145.33+70.33=215
Specimen 3	10	105	5	1:2	150.33+70.33=220

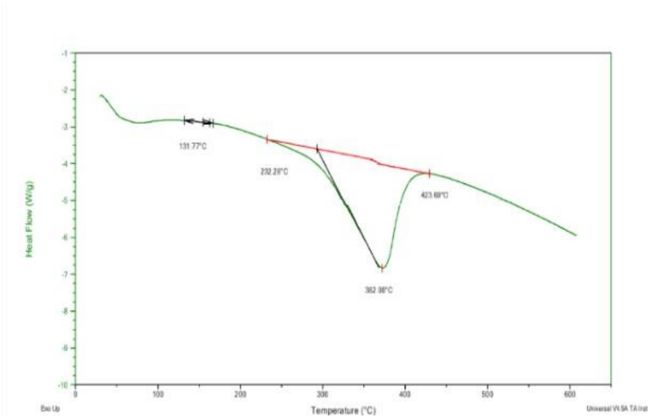
Table 1: Composites Ratios

3.Thermal Testing

3.1 Differential Scanning Calorimetry (DSC)

Differential Scanning Calorimetry (DSC) provides a valuable perspective on the thermal characteristics of natural fiber-reinforced composites with the addition of rice husk powder. Through the measurement of heat flow changes during heating or cooling, DSC reveals essential thermal properties that are crucial for a wide range of applications. The glass transition temperature, which indicates the transition from rigidity to rubberiness, is instrumental in assessing dimensional stability. Moreover, DSC allows for the examination of crystallization behavior in semi-crystalline polymers, facilitatingprocess optimization and long-term performance prediction. The determination of melting and decomposition points establishes the operational limits, preventing potential failures. By analyzing the curves of pure polymer and composite materials, DSC also provides insights into the interaction between fibers and the matrix, which is vital for evaluating the effectiveness of interfacial bonding. Ultimately, DSC enables the acquisition of valuable knowledge regarding thermal stability, crystallinity, and the synergy between fibers and the matrix. This knowledge paves the way for the optimized design and processing of sustainable and high-performance

3.2 Differential Scanning Calorimetry (DSC) of Natural Fiber Composite Bars Reinforced with Rice Husk



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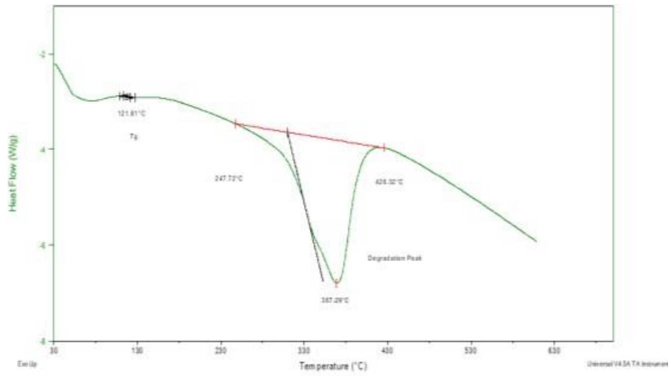
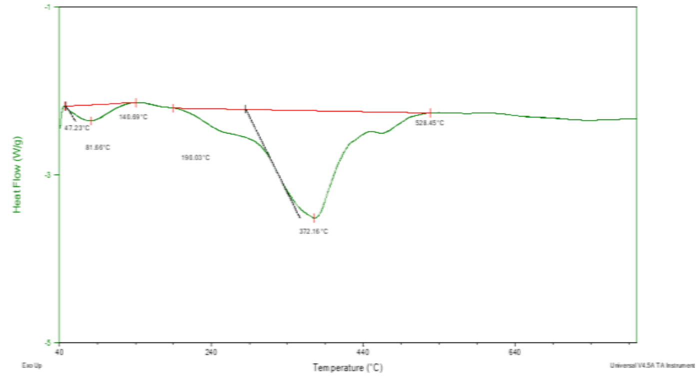
Graph 1: 210g(Resin+Hardner+3gRice husk)



Graph 2: 215g (Resin + Hardner)



Graph 3: 220g (Resin+Hardner+5g Rice Husk)

The analysis of the natural fiber composite bar reinforced with rice husk using Differential Scanning Calorimetry (DSC) reveals important thermal properties. The glass transition temperature (Tg) falls within the range of 121.81°C to 140.069°C, indicating the temperature at which the polymer chains in the composite start to gain mobility. This transition is observed during the second heating cycles, with temperatures ranging from 190.03°C to 528.45°C and 232.28°C to 423.69°C. The Tg value indicates a potential change in the material's stiffness and flexibility. Furthermore, all three samples display a wide exothermic peak, varying from 367.29°C to 382.06°C, which suggests thermal decomposition events likely associated with the degradation of natural fibers and rice husk. This information, when combined with TGA data (if available), can offer valuable insights into the thermal stability of the composite material. Particularly, the (Tg) value provides useful guidance for applications where maintaining dimensional stability is crucial, as the material should retain its shape below this temperature.

Conclusion

1. The TGA examination demonstrated two primary weight loss stages: initial moisture loss at approximately 120°Cand a more substantial stage between 320°C and 620°C, indicating the decomposition of natural fiber and rice husk.

2. This implies that the rice husk content has an impact on the thermal behaviour of the composite. DSC analysis revealed the glass transition temperature (Tg) ranging from 121.81°C to 140.069°C, signifying the onset of polymer chain mobility.
3. A broad exothermic peak between 367.29°C and 382.06°C indicates the thermal decomposition of natural fibersand rice husk.
4. The combined TGA and DSC data offer valuable insights into the thermal stability of the composite.
5. The Tg value is particularly beneficial for applications that necessitate dimensional stability at lower temperatures.

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