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Mechanical Characterization of Sustainable Brake Pad Composites Using Groundnut Shell Powder

Mr. Ashok More[1] Mr. Ishan Kharmate[2] Mr. Samir Kuthwad[3]
Mr. Omkar Manjali[4] Mr. Aditya Khirid[5] Prof. Mitali Gore[6]
Students, Department of Mechanical Engineering [1,2,3,4,5]
Lecturer, Department of Mechanical Engineering [6]
Zeal Polytechnic, Pune, Maharashtra, India

Abstract: *This study focuses on developing and evaluating sustainable brake pad Sustainable material by utilizing groundnut shell powder as a reinforcing material. Our focus is Eco friendly material is used for break pads in a vehicle to minimize the cost of break pad and support agree culture waste. The composite samples were developed by utilizing groundnut shell powder with varying compositions and then processed through compression molding and post-curing. The making of differnts types of plates of a groundnut 10,15,&20 % for the measure their properties mechanical and physical properties, including density, hardness, ash content, water absorption, tensile strength, and compressive strength, by following the standards set by ASTM. The research work was conducted by performing experiments to obtain the results. From the experimental results, it was found that the making plate and testing in a laboratory like mechanical properties should be observed reading as a density value of 1.05 g/cm³, hardness value of around 60 Shore D, ash content value of 44.08%, and water absorption value of 40.28%. Moreover, the Created material was observing that o exhibit a tensile strength value of 0.76 N/mm² and a compressive strength value of 157.16 kg/cm². During the testing the result will found is density, ash content, and water absorption properties, and the optimized composition was found to exhibit good structural stability. From the results, groundnut shell powder can use for making a break pad for the material we choosed their result we are get correctly. For a making a brake pad material exhibits good potential to be an alternative to traditional composite materials. This research work contributes to the development of sustainable and economical composite material*

Keywords: Brake pad. Groundnut Shell Powder ,Brake Pad Composite Materials, Sustainable Materials, Natural Fiber Reinforcement, Mechanical Characterization, Eco-friendly Brake Pads, Agricultural Waste Utilization

I. INTRODUCTION

After reading that , in current Scenarios Brakes Pad play a important role in ensuring driving safety. Brake pads create the friction necessary for slowing down or stopping a vehicle, and they're made from a variety of materials. The best material for brake pads is one that has stable properties, high durability, mechanical strength and thermal resistance. Traditionally, various combined materials: metal; ceramic; and; synthetic. While all three types of brake pads can deliver sufficient performance, each type emits fine particulates into the environment when the vehicle is in use. Because each type of brake pad uses non-renewable and toxic materials, it was are searched the other option for a to replace them. Researching composite materials based on agricultural waste products and natural fiber reinforcements is the result of an increase in demand for green materials.

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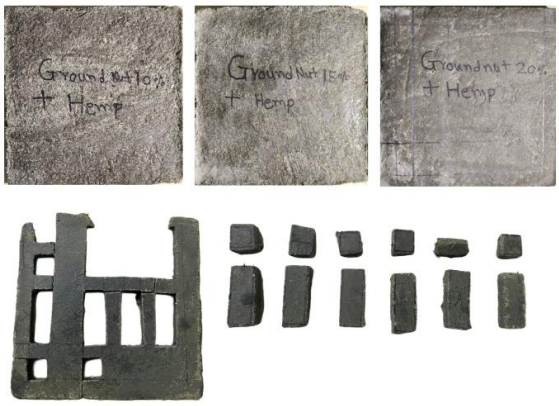

Fig. 1. Ground nut Composite Plate

These composites have advantages is less cot and more biodegradability and lower density. Groundnut shell powder is an agricultural waste that can be used in reinforcing composite materials due to its lightweight nature and ability to create a composite with bonding agents. The objective of this project is to create a more environmentally friendly brake pad using a combination of groundnut shell powder, hemp fibers and all required materials. Once the new material is created, it will be tested for mechanical and physical performance to determine if it has the potential to replace current brake pads on the market.

II. LITERATURE REVIEW

After a reading some serval paper about this experimental The research is mainly focused on developing new materials from natural fibers and agricultural waste without reducing performance and efficiency. **Mollaei & Partovinia (2026)** examined brake pad composites without copper content but steel fibers and concluded that the material had steady friction characteristics with enhanced wear resistant qualities. This study showed relevant how important it is to maintain performance standards without using environmentally hazardous materials. **Naidu et al. (2020)** conducted a study on temperature effect on the related pad by making and discovered that although plant fibers have environmental advantages, performance could be adversely impacted by temperature. This shows how crucial it is to combine different materials and optimize them accordingly. **Naidu et al. (2022)** analyzed hemp fiber-based brake composites and came up with the findings that natural fibers could give satisfactory as well as low wear properties if processed correctly friction characteristics was good. But it all depended on the materials used. In their 2025 study, Gore and colleagues explored a variety of natural fillers including peanut shells, coconut shells, and walnut shells in the formulation of polymer composites. It was seen that of frictional properties; however, the specific performance characteristics of the tested materials varied based on the specific natural filler type used. **Karakaş and colleagues (2024)** researched the mechanical strength and thermal stability of composite materials developed with hemp as a reinforcement medium. Their results demonstrated that materials created using hemp to reinforce the composite exhibited superior mechanical and thermal properties when compared to alternative composite materials. of the composite made with hemp. **Dirisu and colleagues (2024)** used agricultural waste materials to create brake pads. Their work is to be create the properties of the material made from agricultural and village e-waste were equal to those of commercially available brake pads and had no negative environmental impacts; however, they noted potential issues related to absorption of water and inconsistency of the materials. Therefore, it was seen that ; however, challenges remain regarding optimizing the compositional makeup, ensuring good bond strength, and ensuring accurate testing protocols for the resulting naturally brake pads. Convent, this study will Find these issues through the creation of an effective composite mixture.

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III. MATERIALS

A. Groundnut Shell Powder

The groundnut shell powder used in the study came from peanut shells after studying we making and choose were thrown Seen after that is we be removed. The peanut shells were cleaned and dried to ensure no excess dust or materials were left on the shells. Once dried, the it make like powder then ground into powder and sieved; so all particles had the same size for proper homogenization and adhesion of the Sustainable . This organic filler was considered a sustainable option due For its minimum weight.

Fig. 2 Groundnut Shell Powder

B. Hemp Fiber

The hemp fiber utilized in the research was obtained via natural sources. Material are before washed/dried to remove extraneous materials. Fibers are cut small piece like a thin wires to ensure that they were mixed uniformly with the rest of the composite materials. Hemp fibers were selected for their Good mechanical properties And mix with nature easliye without any type of explosive when combined with other materials.

Fig. 3 Hemp Fiber

C. Graphite Shell Powder

A friction controlling agent, is fixed with other our make material materials. The fine grind of graphite powder makes it easier to mix with the other constituents of the cvm composite. The graphite helps to provide consistent friction continuity during braking, thereby reducing the chances of an abrupt change in brake performance.

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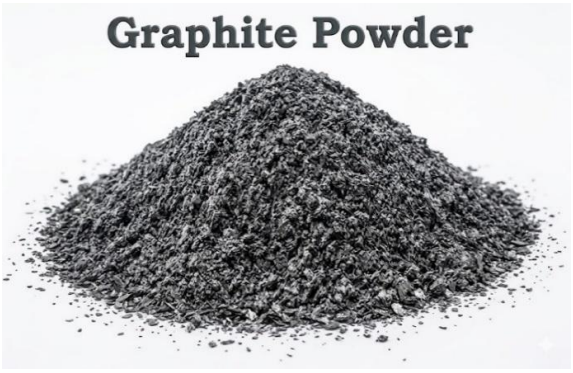

Fig. 4 Graphite Powder

D. Vermiculite

The vermiculite is good and reliable from nature as a mineral that can after that we make it small like powdered before adding it to the composite materials' formulation. The use of vermiculite was for the primary purpose of improving the thermal stability and reducing the high density overall Sustainable material was good characteristics with respect to braking. Due to its natural mineral formation, vermiculite is considered to provide high levels of thermal stability, which is why it was chosen for use as an ingredient within the composite material for braking applications.

Fig. 4 Graphite Powder

IV. METHODOLOGY

The method employed for composite manufacturing was executed in sequence from start to finish. Initial action taken was separating out those materials to be utilized to manufacture the composite: both the binder material and the natural hemp fibers used were sorted based on how much of each material Was ensured that is the would operate effectively throughout the composite manufacturing process. The second step of the process was manually mixing the binder material with the natural hemp fibers together in order for the fibers to incorporate into the binder material effectively when they are subsequently Sustainable materials . In the third step, after mixing, the combined mixture is put into a hydraulic press tool to compress the mixture (called compression molding) into a complete composite material that is then tested for its strength with an applied pressure using the hydraulic press. The result material a solid Sustainable composite material and was visually examined for verification of the texture, where different textural characteristics were Found is the aim of both they are mix each ither for making of (the mixture of the materials) were distributed within the hydraulic press while processing. Drying of the completed composite material occurred by placing it into an oven so that all of the moisture was removed from the composite. The process has successfully yielded a product (the

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composite) from its original two primary component parts (the components in this process are referred to as the binder material and the natural hemp fibers).

Image. 6 : Methodology

V. RESULT

After the conducted Experimental data was obtained from certified laboratory testing (Dutech India Pvt. Ltd.), using ASTM and ISO standards. Compositions were compared: Standard Groundnut–Hemp composite GFRC-1, GFRC-2, GFRC-3 (with varying walnut/hemp ratios)

Composition	Density (G / CC)	Ash Content (%)	Water Absorption (%)
GFRC-1 (Groundnut/Hemp 10%)	1.05	44.08	40.28
GFRC-2 (Groundnut/Hemp 15%)	1.14	46.23	29.13
GFRC-3 (Groundnut/Hemp 20%)	0.98	46.55	44.37

Table 7: Physical Properties of Developed Composites

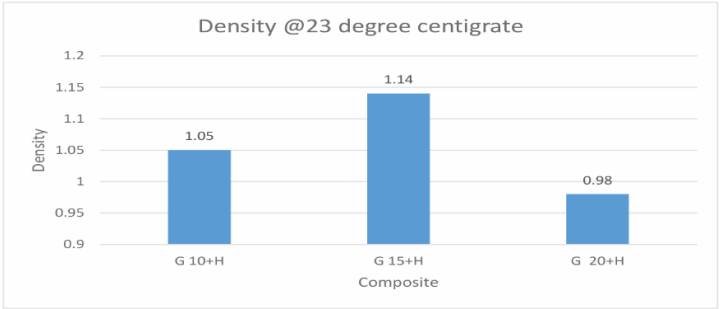

Fig. 8 : Density Comparison of Groundnut–Hemp and GFRC Composites

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The Groundnut Hemp composite has the highest density. This is because it is the most compact material. GFRC-1 shows the lowest density because it contains more hemp fibers compared to the other composites. The presence of more hemp fibers in the material reduces the density of the composite material. Hemp is a lightweight material with a hollow structure. GFRC-2 shows the highest density. This is because it contains an equal amount of Groundnut Hemp; therefore, it is the most compact material. GFRC-3 shows intermediate density. The presence of more groundnut in the material makes it heavier compared to hemp. Groundnut is harder compared to hemp.

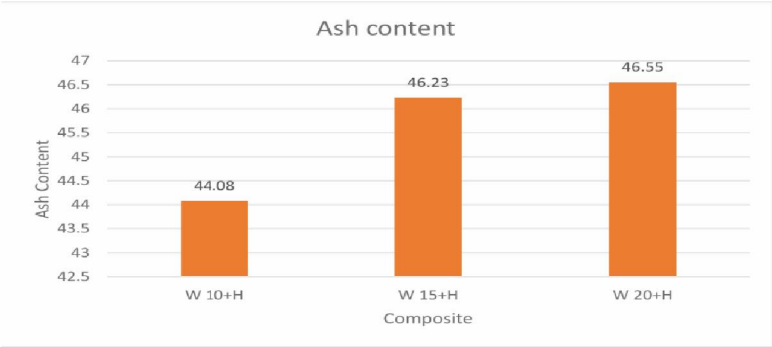

Fig. 9 : Ash content Comparison of Composites

Baseline composite has the lowest ash content. However, baseline composite has a high percentage of combustible organic content. GFRC-1 shows a significant increase in ash content and then maintains a high percentage in GFRC-2 & GFRC-3. The high percentage of ash in hybrid composites indicates the contribution of inorganic fillers to these hybrid composites, resulting in improved thermal stability and friction layer formation

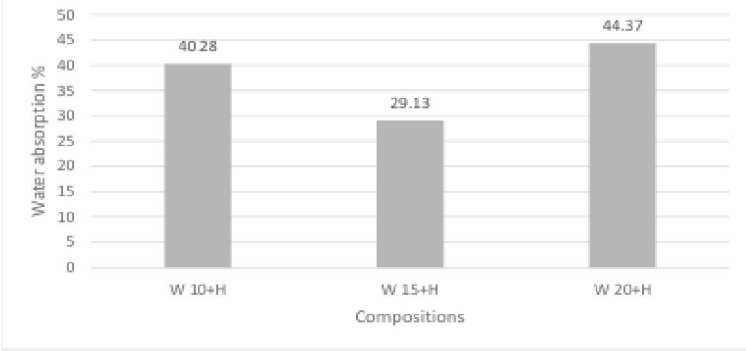

Fig. 10 : Water absorption Comparison of Composites

Baseline composite has the maximum water absorption capacity. The moisture path is more in this composite. Water absorption capacity increases in higher walnut shell content combinations such as G 15 + H and G 20 + H.

VI. ACKNOWLEDGMENT

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