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# EVALUATION OF THE MECHANICAL PROPERTIES OF STYRENE BUTADIENE RUBBER(SBR)/BANANA FIBRE(BF) COMPOSITES

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## ABSTRACT

*Tensile strength, rip strength, abrasion loss, hardness, and thermal conductivity are the main characteristics of Styrene-Butadiene Rubber (SBR) composites that are examined in this work as a function of increasing banana fibre loading. Because banana fibres are reinforcing, adding them to the SBR matrix initially increases tensile and tear strength. However, there is an ideal concentration at which fibre aggregation and poor interfacial bonding cause these qualities to drop. Abrasion loss increases with higher loadings because of insufficient fibre dispersion, but it decreases with moderate fibre concentration, indicating enhanced wear resistance. Fibre addition improves the composites' hardness up to a certain point, beyond which adding too many fibres causes inconsistent results and lower hardness. It is discovered that as fibre counts increase, thermal conductivity decreases.*

**KEYWORDS**—*SBR composites, tensile strength, thermal conducutivty.*

## I. INTRODUCTION

I. INTRODUCTION

Polymers are widely used for different applications in the current world. Styrene-butadiene rubber (SBR) is a synthetic polymer composed of styrene and butadiene, widely used in various industries. Developed as a substitute for natural rubber, SBR is known for its excellent abrasion resistance and aging stability. It is extensively utilized in the production of automobile tires, conveyor belts, and footwear due to its durability and flexibility. The polymerization process of SBR can be tailored to achieve different mechanical properties, making it versatile for diverse applications. Despite its advantages, SBR's performance can be affected by extreme temperatures and oil exposure, necessitating careful selection for specific uses. Banana fibre composite materials are eco-friendly alternatives derived from the fibres of banana plants, known for their impressive strength and durability. These composites are utilized in various applications, including automotive parts, construction materials, and biodegradable packaging. Their lightweight nature and high tensile strength make them an attractive choice for industries aiming to reduce environmental impact while maintaining material performance. Additionally, banana fibre composites are biodegradable, contributing to sustainability and reducing waste.

A growing number of natural fibres are being used as a result of environmental concerns. Because of concerns about sustainability, many technical applications also choose materials based on natural fibres. One application for which this kind of composite material may be examined is the inside of automobiles.

## II. MATERIALS AND METHODS

### *A. Raw Materials*

The materials used are Styrene Butadiene Rubber(SBR), Carbon Black(CB) and Banana Fibre(BF). The concentration or loading of Banana Fibre is varied from 0phr,10phr,20phr,30phr,40phr,50phr. The rubber chemicals added are stearic acid, zinc oxide, sulphur etc.

| Component | Amount (phr) |
|---|---|
| SBR (Styrene-Butadiene Rubber) | 100 |
| Banana Fibre | 10,20,30,40,50 |
| Zinc Oxide | 3 |
| Sulfur | 1 |
| CBS(N-Cyclohexyl-2-benzothiazolesulfenamide) | 1 |
| Carbon Black | 10 |
| Processing Oil | 5 |

**Table 1 Formulation of the SBR/BF Composite**

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The naming of the composite based on the weight percentage of banana fibre are as follows.

| Composite | Wt% of Banana Fibre (phr) |
|---|---|
| S1 | 10 |
| S2 | 20 |
| S3 | 30 |
| S4 | 40 |
| S5 | 50 |

**Table 2 Naming of SBR/BF Composite**

*B. Preparation of Elastomer Composites.*

The preparation of Styrene-Butadiene Rubber (SBR) and banana fibre composites using a two-roll mixing mill involves a systematic process. First, the SBR rubber is masticated on the mill to achieve a uniform consistency. Next, pre-treated banana fibres are gradually added to the masticated SBR rubber to ensure even dispersion. The milling process continues with repeated sheeting and folding to achieve a homogeneous composite blend. Finally, the mixed composite is sheeted out to the desired thickness, ready for further processing or molding into specific shapes.

A two roll mill was used to prepare the rubber composites. The standard conditions were maintained. A hydraulic press was used to get the polymer sheet pressed.

## III. RESULTS AND DISCUSSION

The various tests were performed on the prepared elastomer composites and the results are discussed below.

*A. Stress-Strain Characteristics*

The variation of tensile strength with the variation of banana fibre is shown in the following graph. As the concentration of banana fibre in Styrene-Butadiene Rubber (SBR) composites is increased, a notable variation in tensile strength is observed. Initially, the tensile strength tends to improve due to the reinforcing effect of the banana fibres, enhancing the overall composite structure. However, beyond a certain fibre concentration, the tensile strength may begin to decrease. This decline is often attributed to fibre agglomeration, poor interfacial bonding, and inadequate stress transfer between the fibres and the rubber matrix. Therefore, optimizing the fibre concentration is crucial to achieving the best balance of mechanical properties in SBR-banana fibre composites.

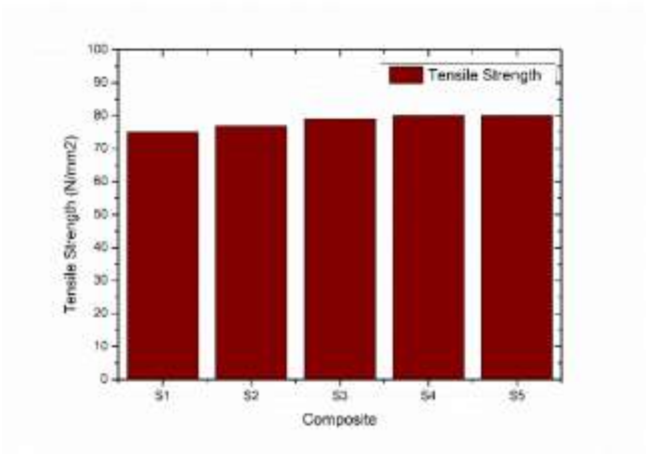


**Figure 1 Variation of Tensile Strength**

*B. Tear Strength*

The following graph displays the variation in tear strength.There is a clear pattern of fluctuation in the tear strength of Styrene-Butadiene Rubber (SBR) composites when the concentration of banana fibre is increased. Because of the fibres' ability to resist crack propagation, the tear strength often increases at lower fibre concentrations. An excellent balance between the rubber matrix and the reinforcing fibres may be reflected in the tear strength, which may reach an optimal point as the fibre concentration increases. However, due of fibre aggregation and inadequate bonding, additional increases in fibre content may result in weak spots within the composite and a loss in tear strength. Thus, in order to enhance the tear strength of SBR-banana fibre, it is imperative to have the ideal fibre concentration.

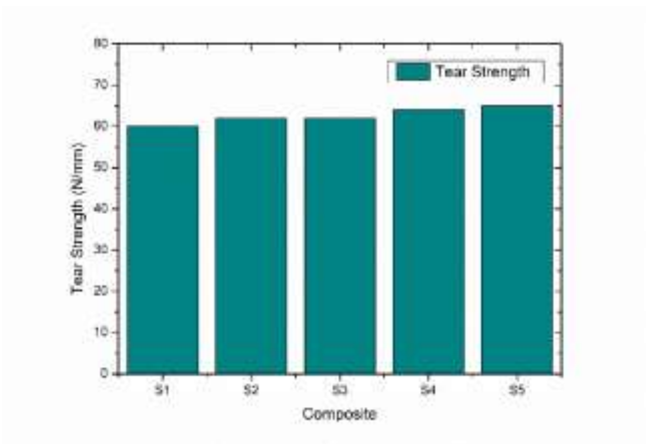


**Fig 2 Variation of Tear Strength**

*C. Abrasion Loss*

The abrasion loss variation for the various composites under study is displayed in the accompanying graph. The concentration of banana fibres has a major impact on the variance of abrasion loss in banana fibre composites made of Styrene-Butadiene Rubber (SBR). Because of their

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reinforcing function, banana fibres tend to reduce abrasion loss at lower concentrations, improving the wear resistance of the composite. The abrasion loss may minimize as the concentration of fibres rises, showing ideal fibre dispersion and rubber matrix interaction. But over this ideal threshold, too much fibre can result in more abrasion loss. Poor fibre dispersion, agglomeration, and weaker interfacial bonding, which impair the composite's resistance to wear, are frequently the cause of this rise.

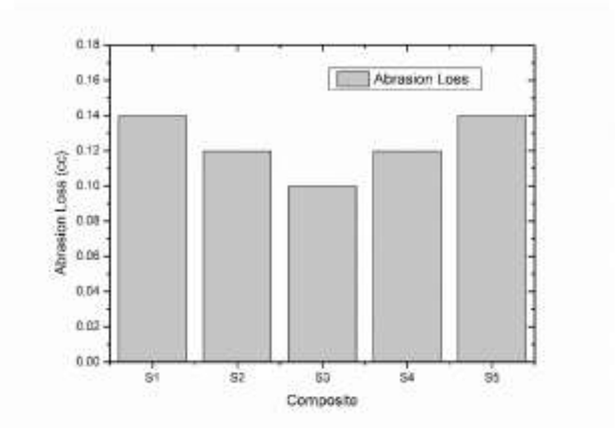


**Figure 3 Variation of Abrasion Loss**

*D. Hardness*

The variance in Hardness values of several composites is displayed in the accompanying graph. The concentration of banana fibres in Styrene-Butadiene Rubber (SBR) banana fibre composites affects how hard they are. Because of their stiffening action, banana fibres often increase the hardness of the composite at lower concentrations. The hardness may climb even more as the fibre content does, eventually reaching an ideal point where the fibres are evenly distributed and successfully strengthen the rubber matrix. However, more fibres may result in a decrease in hardness over this ideal percentage. Fibre aggregation and inadequate interfacial bonding, which result in irregularities within the composite structure, are frequently the cause of this drop.

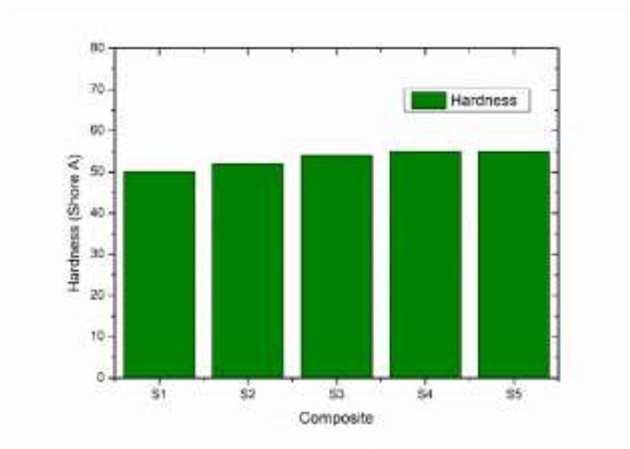


**Figure 4 Variation of Hardness**

*E. Thermal Conductivity Studies*

The following graph shows the variation of thermal conductivity. The thermal conductivity of Styrene-Butadiene Rubber (SBR) banana fibre composites is significantly affected by the concentration of banana fibres. Initially, the addition of banana fibres, which are natural insulators, tends to lower the thermal conductivity of the composite due to the inherent low thermal conductivity of the fibres. As the concentration of banana fibres increases, the overall thermal conductivity of the composite decreases further, reflecting the dominant insulating nature of the fibres. This decrease continues until an optimal fibre concentration is reached, where the insulating effect is maximized, and the composite exhibits the lowest thermal conductivity. However, beyond this optimal point, further increasing the fibre content can lead to agglomeration and poor dispersion of fibres, which may create thermal bridges and defects within the composite. These imperfections can slightly increase the thermal conductivity due to localized heat transfer pathways. Additionally, excessive fibre content may disrupt the homogeneity of the rubber matrix, further affecting thermal properties. Therefore, achieving a balance in fibre concentration is crucial to optimizing the thermal insulation properties of SBR-banana fibre composites. Properly managing the dispersion and interaction of fibres within the matrix ensures that the composite retains its desired low thermal conductivity. This balance is essential for applications requiring effective thermal insulation.

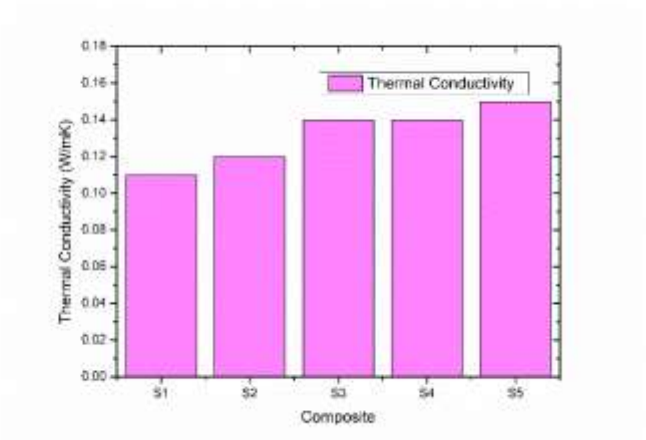


**Figure 5 Thermal Conductivity**

It is seen from the graph that the thermal conductivity values increases nominally for S3 composites and then it increases for S5 composites. The reason for the minute increase in value is due to the fact that the banana fibre being a natural fibre will not contribute to much increased thermal conductivity. The thermal conductivity tests were conducted on Lee Disc apparatus.

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**Fig 6 Lee Disc Apparatus**

*F Tribological Properties*

The tribological performance of styrene-butadiene rubber (SBR) composites reinforced with varying amounts of banana fibre is being discussed in this section. The analysis is conducted using a pin-on-disc apparatus, a widely used method for evaluating the friction and wear characteristics of materials.The equipment used is Pin-on-Disc Apparatus. The pin-on-disc test setup includes a stationary pin (specimen) in contact with a rotating disc under a controlled load.

Test Conditions
- Load: 10 N
- Sliding Speed: 1 m/s
- Sliding Distance: 1000 m
- Environment: Room temperature

One important factor in tribological research is the coefficient of friction(COF). In comparison to the composites with larger fibre contents, the SBR composite with the lowest banana fibre concentration (10 phr) had a higher friction coefficient. The friction coefficient trended downward as the amount of banana fibre rose. This phenomenon can be explained by the composite's decreased flexibility and greater stiffness, which results in less deformation under load.

It was discovered that as the amount of banana fibre in the composites increased, the wear rate decreased. The maximum wear rate was seen in the 10 phr banana fibre composite, suggesting that a substantial amount of material was removed during the sliding process. On the other hand, the banana fibre composite with a 30 PHr showed the least wear rate, indicating improved resilience to wear. The reinforcing effect of the banana fibres, which aid in load distribution and lower the rate of material removal, is probably what's responsible for this improvement in wear resistance.

**Fig 7 Pin On Disc Apparatus**

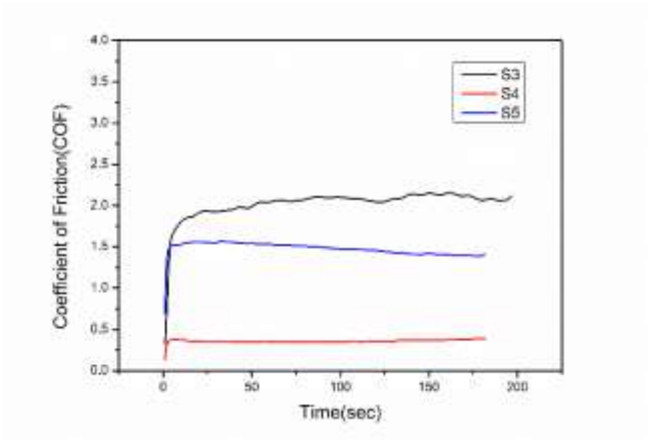


**Fig 8 COF Vs Time**

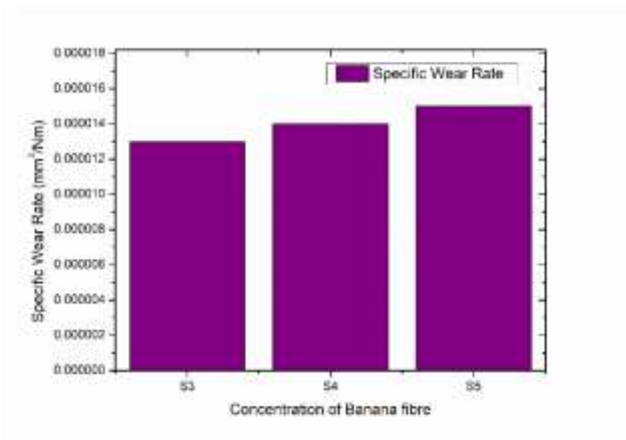


**Fig 9 Variation of specific wear rate**

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## CONCLUSION

From the above test results, it is seen that the tensile strength increases but in a very small way when the banana fibre loading is increased in the composite. The variation of tear strength also is in a very slow manner as the fibre content goes up in the composite. The abrasion loss values in cc is also plotted for different composites and the main factor contributing the abrasion loss is the presence of carbon black. The hardness values does not show much change as increasing natural fibre content has got less effect on the composite.

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