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Mechanical and Damping Properties of Rubber Reinforced With Natural Fibre

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ABSTRACT
The natural fibre reinforced dampers were developed using natural rubber, sisal, and banana fibre composites on account of their low cost, low density, high specific strength and modulus, no health risk, easy availability in some countries and renewability. Rubber products generally undergo dynamic stressing during service which is very much beneficial for dynamic load application. This paper deals with the design, analysis, and manufacturing of three natural fibre reinforced damper i.e., natural rubber composite with banana fibre, natural rubber composite with sisal, and composites of banana fibre and sisal with natural rubber. A series of performance tests were conducted on the specimens created. Through the performance tests, it was confirmed that the developed dampers had better damping characteristics, high tensile strength, high strength to weight ratio, and recyclability.

KEYWORDS: *natural fibre reinforced damper, sisal and banana fibre, composite*

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I. INTRODUCTION

After the industrial revolution, synthetic component and chemistry have been developed to increase efficiency to fulfil the needs in textile production. It became one of many industries highly affecting on the environment, especially water and soil pollution. Textile production processes release some chemicals that contaminate water and soils resources, including fume emission. Cultivation of natural fibre, including fibres from plants and animals, requires the use of hazardous pesticide and chemical fertilizers to control and increase the quality.

Some of chemicals used during the process are toxic, not-biodegradable and thus change the physical environment. These unbalance natural resources resulting draught, heat, and high temperature of the world's atmosphere. Textile production processes are now shaping toward the concept of environmental-friendly and sustainable development. These ideas are not very new in textile industry. The progresses have been improving ranges of natural and environmental (eco)-friendly textile processes. Many efforts have been made in sciences and technology to develop environmental-friendly process to sustain relationship with the ecosystem. However, alternative materials should be considered. This research proposes an option of natural fibre, by-product from banana fruit cultivation, by suggesting a use of left over banana trunk as fibre source in textile process.

1.1 BANANA INFORMATION

Banana is in Musa family. Banana plant is a large perennial herb with leaf sheaths that form pseudo stem. Its height can be 10-40 feet (3.0-12.2 meters) surrounding with 8-12 large leaves. The leaves are up to 9 feet long and 2 feet wide (2.7 meters and 0.61 meter). Its fruits are approximately 4-12 inches (10.2-30.5 centimetres). Different parts of banana trees serve different needs, including fruits as food sources, leaves as food wrapping, and stems for fibre and paper pulp. It is available throughout Thailand and Southeast Asian, India, Indonesia, Malaysia, Philippines, Hawaii, and some Pacific islands. This source of fibres provides great strength, used generally in particular products, such as tea bags and Japanese yen notes. Typically, banana plants are grown in 3 types; (1) food source, (2) decorative plants, and (3) starch and fibres sources (abaca). Abaca fibre has a long history as a leading cordage fibre of the world, known as Manila hemp. Abaca is one kind of banana plants. The fibre is obtained from outer layers from the stalks of the abaca plant. It I light, strong, and durable. After extraction and dry, it provides a white lustrous colourfibre. One particular characteristic of the abaca fibre over all other fibres of its class is the great strength and resistance to the action of water, therefore its particular adaptability for marine ropes. However, abaca's fruit is not human food source. It is specifically grown for fibre cultivation. Instead of growing banana tree only for fruit consumption and discard the trunks, the use of banana fibres after the fruits are harvested should be explored. Therefore, the focuses of this research is on banana fruit plant.

Table 1 Banana fibre properties

Fibre properties	
Tenacity	29.98 g/denier
Fineness	17.15 Denier
Moisture Regain	13.00 %
Elongation	6.54
Alco-ben Extractives	1.70 %
Total Cellulose	81.80 %
Alpha Cellulose	61.50 %
Residual Gum	41.90 %
Lignin	15.00%

The data is compiled of information from: (1) Fibre Properties.Philippines Textile Research Institute (2005), (2) ThailandTextile Institute (2008), and this research experiment.

1.2. EXPERIMENT

Thai indigenous banana plant in Musa family was selected for fibre extraction. The research employed motor drive invented machine to extract banana sap, banana pulp, and banana fibre. After cleaning, banana fibre was air dried. The researcher compared the fibre collection methods, fermented extraction and fresh extraction. Then, the fibres were combed and carded inregular natural fibre production process. The fibre property tests include fibre fineness, tensile strength, elongation, and moisture regain. The research utilized open-ended spinning process for this study.

1.3 BANANA FIBRE COLLECTION PROCESS

In banana plantations, after the fruits are harvested, the trunks or stems will be discarded. These wastes provide obtainable sources of fibres, which leads to the reduction of other natural and synthetic fibres' production that requires extra energy, fertilizer, and chemical. The properties of banana fibre are good absorbent, highly breathable, quickly dry with high tensile strength.

Figure 1.3.1 Banana Trunk

1.4 Banana Fibre Extraction

Historically, banana fibre was extraction by hand. The process requires a long period of time and skilled practice to collect fibres. This research employed an invented motor-driven machine as extraction tool.

Figure1.4.1. Motor-driven machine

1.5 SISAL FIBRE

Sisal fibre is one of the most widely used natural fibres and is very easily cultivated. It has short renewal times and grows wild in the hedges of fields and railway tracks. Nearly 4.5 million tons of sisal fibres are produced every year throughout the world. Tanzania and Brazil are the two main producing countries. Sisal fibre is a hard fibre extracted from the leaves of the sisal plant (Agave sisalana). Though native to tropical and sub-tropical North and South America, sisal plant is now widely grown in tropical countries of Africa, the West Indies and the Far East. A sketch of a sisal plant is shown in Fig. 1 and sisal fibres are extracted from the leaves. A sisal plant produces about 200±250 leaves and each leaf contains 1000±1200 fibre bundles which is com-posed of 4% fibre, 0.75% cuticle, 8% dry matter and 87.25% water. So normally a leaf weighing about 600 g will yield about 3% by weight of fibre with each leaf containing about 1000 fibres. The sisal leaf contains three types of fibres : mechanical, ribbon and xylem. The mechanical fibres aremostly extracted from the periphery of the leaf. They have a roughly thickened-horseshoe shape and seldom divide during the extraction processes. They are the most commercially useful of the sisal fibre. Ribbon fibres occur in association with the conducting tissues in the median line of the leaf. Fig. 1 shows a cross-section of a sisal leaf and indicates where mechanical and ribbon fibres are obtained. The related conducting tissue structure of the ribbon fibre gives them considerable mechanical strength. They are the longest fibres and compared with mechanical fibres they can be easily split longitudinally during processing. Xylem fibres have an irregular shape and occur opposite the ribbon fibres through the connection of vascular bundles as shown in Fig. 1.3.1. They are composed of thin-walled cells and are therefore easily broken up and lost during the extraction process. The processing methods for extracting sisal fibres have been described by Chand et al. and Mukherjee and Stayanarayana. The methods include (1) retting followed by scraping and (2) mechanical means using decorticators. It is shown that the mechanical process yields about 2±4% fibre (15 kg per 8 h) with good quality having a lustrous colour while the retting pro-cess yields a large quantity of poor quality fibres. After extraction, the fibres are washed thoroughly in plenty of clean water to remove the surplus wastes such as chlorophyll, leaf juices and adhesive solids.

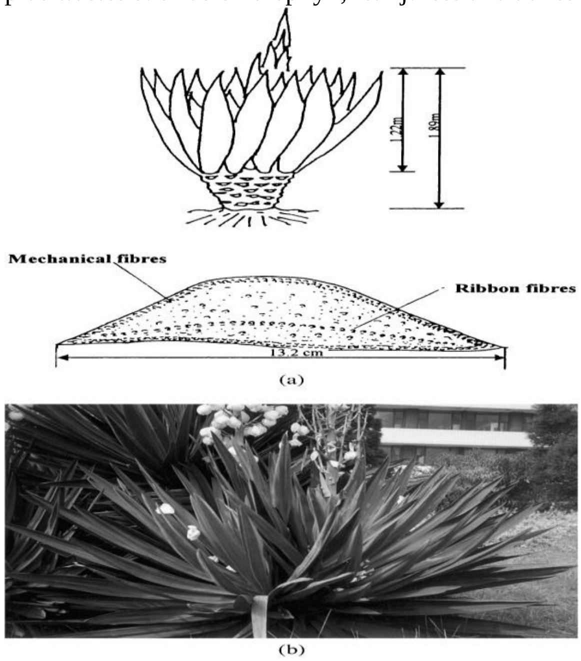

Figure1.5.1. Sisal Plant specifications

The chemical compositions of sisal fibres have been reported by several groups of researchers [4±7]. For example, Wilson indicated that sisal fibre contains 78% cellulose, 8% lignin, 10% hemi-celluloses, 2% waxes and about 1% ash by weight; but Rowell found that sisal contains 43±56% cellulose, 7±9% lignin, 21±24% pentosan and 0.6±1.1% ash. More recently, Joseph et al .reported that sisal contains 85±88% cellulose. These large variations in chemical compositions of sisal fibre are a result of its different source, age, measurement methods, etc. Indeed, Chand and Hashmi showed that the cellulose and lignin contents of sisal vary from 49.62±60.95 and 3.75±4.40%, respectively, depending on the age of the plant. The length of sisal fibre is between 1.0 and 1.5 m and the diameter is about 100±300 mm . The fibre is actually a bundle of hollow sub-fibres.

Properties of sisal fibres: Mechanical, thermal and dielectric properties of sisal fibre have been studied in detail. X-ray diffraction, IR, TG, SEM, DSC, DMA, etc., have been used to determine the characteristics of sisal fibre and provide theoretical support for processing and application of this fibre.

- Interface properties between sisal fibre and matrix: The main purpose here is to modify the fibre-surface structure by using chemical and thermal treatment methods in order to enhance the bond strength between fibre and matrix and reduce water absorption of sisal fibre.
- Properties of sisal-fibre-reinforced composites: The matrix used in sisal-fibre-reinforced composites include thermoplastics (polyethylene, polypropylene, polystyrene, PVC, etc.), thermosets (epoxy, polyester, etc.), rubber (natural rubber, styrene butadiene rubber, etc.), gypsum and cement. The effects of processing methods, fibre length, fibre orientation, fibre-volume fraction and fibre-surface treatment on the mechanical and physical properties of sisal-fibre-reinforced composites have been studied. Also, several theoretical models are given to predict the properties of the composites.
- Sisal/glass-fibre-reinforced hybrid composites: To take advantage of both sisal and glass fibres, they have been added conjointly to the matrix so that an optimal, superior but economical composite can be obtained. The hybrid effect of sisal/glass fibres on the mechanical properties have been studied and explained.

II. MATERIALS AND METHODS

2.1 FIBRES

In this research we are reinforcing natural banana fibre and sisal with natural rubber so as to obtain better damping characteristics, high tensile strength, high strength to weight ratio, and recyclability. The fabricated specimen is of 330x50x6mm in size.

2.2 FABRICATION

2.2.1 INJECTION MOULDING

Injection moulding (British English: moulding) is a manufacturing process for producing parts from both thermoplastic and thermosettingplastic materials. Material is fed into a heated barrel, mixed, and forced into a mould cavity where it cools and hardens to the configuration of the cavity. After a product is designed, usually by an industrial designer or an engineer, moulds are made by a mould maker (or toolmaker) from metal, usually either steel or aluminium, and precision-machined to form the features of the desired part. Injection moulding is widely used for manufacturing a variety of parts, from the smallest component to entire body panels of cars.

2.2.1.1 PROCESS CHARACTERISTICS

- Utilizes a ram or screw-type plunger to force molten plastic material into a mould cavity.
- Produces a solid or open-ended shape that has conformed to the contour of the mould.
- Used to process both thermoplastic and thermosettingpolymers, with the former being considerably more prolific in terms of annual material volumes processed.

2.3. SPECIMEN FABRICATION

In this research work we have manufactured three different specimens i.e.,

- Rubber composite.
- Sisal blended together with rubber composite.
- Banana fibre blended together with rubber composite.

These specimens were created using injection moulding in an industry and were also subjected to various tests to find out their capabilities and properties.

Figure 2.3.1 Specimen Fabrication

2.4 TESTS
The created specimens were subjected various tests i.e.,

- Tensile
- Hardness
- Vibration analysis

Figure 2.4.1 Specimens Tested

Figure 2.4.2 Vibration Analysis of Specimen

III. RESULTS AND DISSCUSSIONS

Properties	**Banana Fibre Reinforced With Rubber**	**Sisal Fibre reinforced With rubber**	**Rubber**
Tensile stress	9.6 N/mm^2	12.8N/mm^2	13.6 N/mm^2
Ultimate Load	250 N	340 N	360 N
Breaking Point	250 N	340 N	360 N
Cross Sectional Area	25 mm^2	25 mm^2	25 mm^2

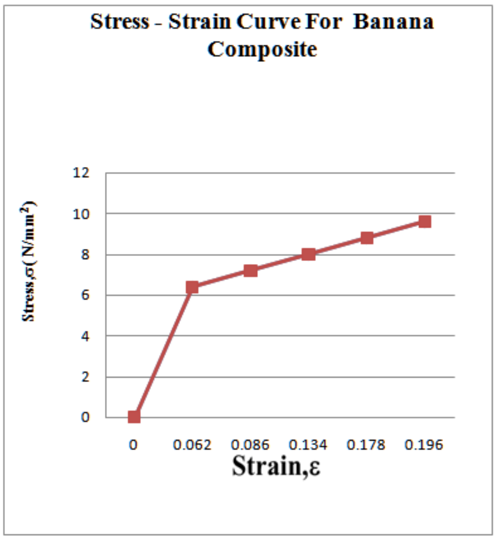

Figure 3.1 Stress – strain diagram for banana composite

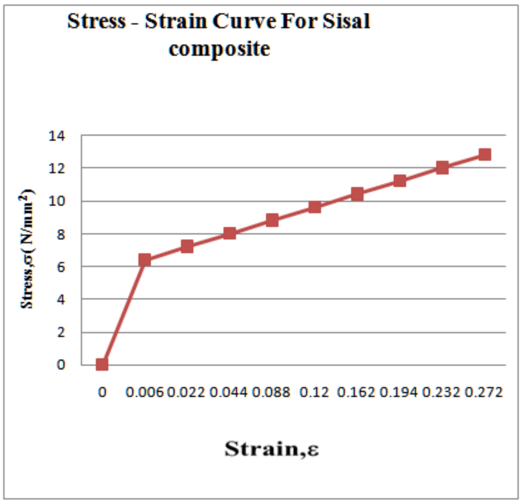

Figure 3.2 Stress – strain diagram for sisal composite

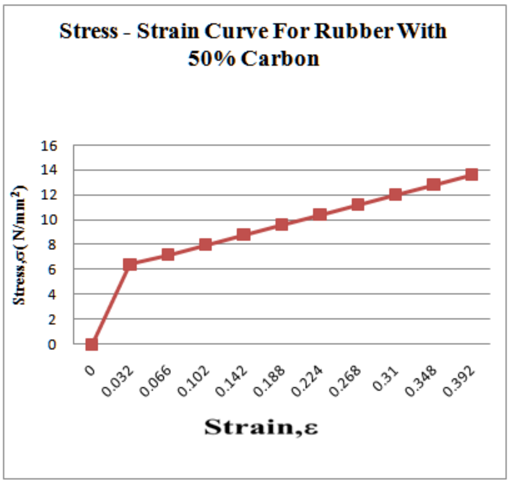

Figure 3.2 Stress – strain diagram for rubber with 50% carbon

3.1 Young's Modulus comparison

Natural Rubber N/mm²	Banana Fibre Reinforced Rubber N/mm²	Sisal Fibre Reinforced Rubber N/mm²
19.33	34.28	21.25

Overall increase in modulus value for banana composite = 77.34%

Overall increase in modulus value for sisal composite = 9.93%

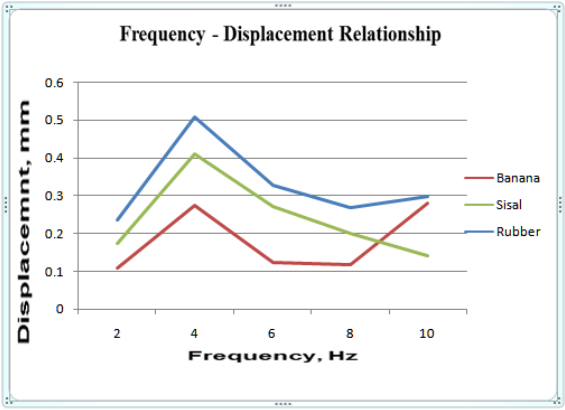

Figure 3.3 Frequency – displacement relationship

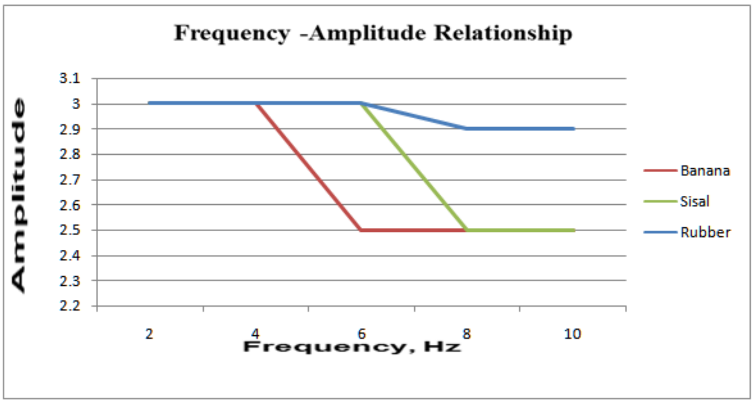

Figure 3.4 Frequency - amplitude relationship

Therefore from the obtained results, it is confirmed that the damper created by blending sisal fibre with natural rubber is having better damping characteristics and strength when compared with other specimens.

IV. CONCLUSION

The chief contribution of this paper is the improvement in the damping characteristics of a damper with the implementation of natural fibres i.e., sisal, and banana fibre blended with natural rubber. Rubber products generally undergo dynamic stressing during service which is very much beneficial for dynamic load application. The natural fibre reinforced dampers developed using natural rubber, sisal, and banana fibre composites also reflects in the field on account of their low cost, low density, high specific strength and modulus, no health risk, easy availability in some countries and renewability.

The created specimens were gone through several tests and through these tests, it was confirmed that the created dampers had better damping characteristics.

REFERENCES

[1] Japan Echo Inc. 2005. Banana Stem Become Denim-like Cloth. Domestic Japanese News Source. 1-6. DOI=http://web-japan.org/trends/science/sci040105.html

[2] Lu, P., Woo, K.C., Liu, Z.T. 2002. Estimation of Whole-Plant Transpiration of Bananas Using Sap FlowMeasurements. Journal of Experimental Botany. 53:375,1771-1779.

[3] Anonymous. 2007. Kijoka Banana Fibre Cloth. KijokaBanana Fibre Cloth Association. Cooperative. Union. 1-7.

[4] Johnston, T. 2003. Banana Paper. The Buzz. Transform Australia. 1-4.DOI=http://ingentaconnection.com/content/oup/exbotj/2002/00000053/00000375/art01771Banana Paper.

[5] Banana Fibre: Environmental Friendly Fabric, UraiwanPitimaneeyakul, King Mongkut's Institute of Technology Ladkrabang, THAILAND.

[6] Sisal Fibre and its composites: a review of recent developments, Yan Li, Yiu-Wing Mai *, Lin Ye, Composites Science and Technology 60 (2000) 2037±2055

[7] Murherjee PS, Satyanarayana KG. Structure and properties of some vegetable fibres, part 1. Sisal fibre. Journal of Materials Science 1984;19:3925±34.

[8] Chand N, Tiwary RK, Rohatgi PK. Bibliography resource structure properties of natural cellulosic fibres Ð an annotated bibliography. Journal of Materials Science 1988;23:381±7.

[9] Tensile Properties Of Natural Fibre-Reinforced Epoxy-Hybrid Composites ,International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.2, Mar-Apr 2012 pp-471-474

[10] F. Kuster and P.E. Gygax, Cutting Dynamics and Stability of Boring Bars, CIRP Annals-Journal of Manufacturing Technology 39 (1990) 361-366.

[11] R.A. Mahdavinejad, A step forward to chatter analysis in turning machines, 13th International Scientific conference on achievements in mechanical and material Engineering, 2005

[12] Linus Andr´en, Lars H˚akansson, Anders Brandt and Ingvar Claesson, "Identification of Dynamic Properties of Boring Bar Vibrations in a Continuous Boring Operation", Journal of Mechanical Systems & Signal Processing 18 (2004) 869-901.

[13] HenrikAkesson, Tatiana Smirnova and Lars H˚akansson, Analysis of Dynamic Properties of Boring Bars Concerning Different Clamping Conditions, Journal of Mechanical Systems and signal processing 23 (2009) 2629- 2647.

[14] Satoshi Ema , Etsuo Marui, Suppression of chatter vibration of boring tools using impact dampers, International Journal of Machine Tools & Manufacture 40 (2000) 1141–1156.

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