MATERIALE PLASTICE
https://revmaterialeplastice.ro
https://doi.org/10.37358/Mat.Plast.1964

Asbestos-Free Brake Lining Material Using Sea Shell

VIJAYASANKAR VINAYAK ARUN SANKAR[1], PARAMASIVAM SURESH[2*]
[1]Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore 641032, Tamilnadu, India
[2]Department of Mechanical Engineering, Muthayammal Engineering College, Rasipuram, Namakkal – 637408, Tamilnadu, India

Abstract: *Due to the extreme health concerns associated with asbestos-based brake linings, researchers are looking at using ecologically friendly bio-based biomaterials as reinforcing agents in composite materials used to make brake pad linings. The goal of this study is to see whether using sea shell (SS) powder in the production of asbestos-free brake lining materials is feasible. The powders were combined with the necessary fillers to make the brake lining. The reinforcing powders' compositions were varied between 20% and 35%, the resin binder's composition was changed between 58 and 43 percent, and the filler metal and curing agents' compositions were kept constant. These ingredients were weighed, prepared, combined, cured, and moulded. The composite materials were tested for water and oil absorption, compressive strength, hardness, and wear. According to the findings, increasing the quantity of reinforcing components increases the water and oil absorption of the samples. With the addition of up to 35% content, the composite's compressive strength increased proportionally. The tested coefficient of friction was found to be within acceptable limits. Furthermore, when mixed with other fillers and restricted, SS powder has shown tremendous promise in the production of brake linings.*

Keywords*: Seashell (SS), brake linings, compressive strength, hardness, wear*

1. Introduction

The One of the main organs that controls a vehicle is the braking system [1]. Brake pads are used to decrease heat and wear produced by mating surfaces coming into contact [2]. Frictional materials used in automobile brake pads have been used for a long time. In the 1870s, Herbert Frood created the first frictional substance, which was made of cotton and bitumen solution [3]. These accumulated dusts are always cleaned off before the old pads or shoes are replaced in a typical brake or clutch repair job, exposing vehicle technicians to asbestos dust [4]. Asbestos particles may become airborne using any of these methods. If the old brake pads are still hard enough to use, technicians may frequently use a bench grinder to smooth off the surface or dissolve the pad's oil and grime. When changing brake pads or shoes, the technician may also polish the pad's face to improve engagement, bevel the grinding wheel edges to minimise noise while in operation, and then drill holes for riveting [5].

These procedures often result in the emission of asbestos particles, which may be breathed, placing the mechanic at risk of illnesses including asbestosis and cancer [6]. As a result, considerable effort has been undertaken to replace asbestos fibres in brake pads. Metal fibres were used in the manufacturing of brake pads in order to reduce pollution [7]. a non-asbestos brake pad material made from agro-waste, using palm kernel shell (PKS) as the filler material The palm kernel shell was chosen above the other agro-wastes because it had more favourable characteristics, according to the authors [8]. As reinforcing materials, bagasse, coconut shell, palm kernel fibres, and palm ash were used to create a non-asbestos brake pad. The chosen reinforcing materials were found to be similar to other commercially available brake pad materials in their research [9].

Seashells, in general, have a higher moisture resistance since they are constantly submerged in saltwater. They have higher corrosion resistance and hardness characteristics by nature, making them wear resistant as well [10]. This is the primary reason why seashell powder was chosen as a filler material for this composite. Furthermore, since the seashell powders are ball-milled and ground into powders, they fill the micropores in the composites created during manufacturing and curing [11]. It produces

**email: suresh.me2004@gmail.com*

defect- free composites, and when a material is defect - free, it has superior physical and mechanical characteristics. A constructed and evaluated a glass fibre reinforced epoxy composite filled with seashell and discovered that the composite may be utilised to make car components, helmets, and other items, as well as that the inclusion of seashell fillers reduces the composites' tensile characteristics [12].

2. Materials and methods

The brake lining material is sea shell, and the binder material is polyamides resin, while the fillers include carbonate, metal filings, and graphite. All materials were sourced from Coimbatore's local marketplaces. The materials were washed and sundried for a week to eliminate contaminants.

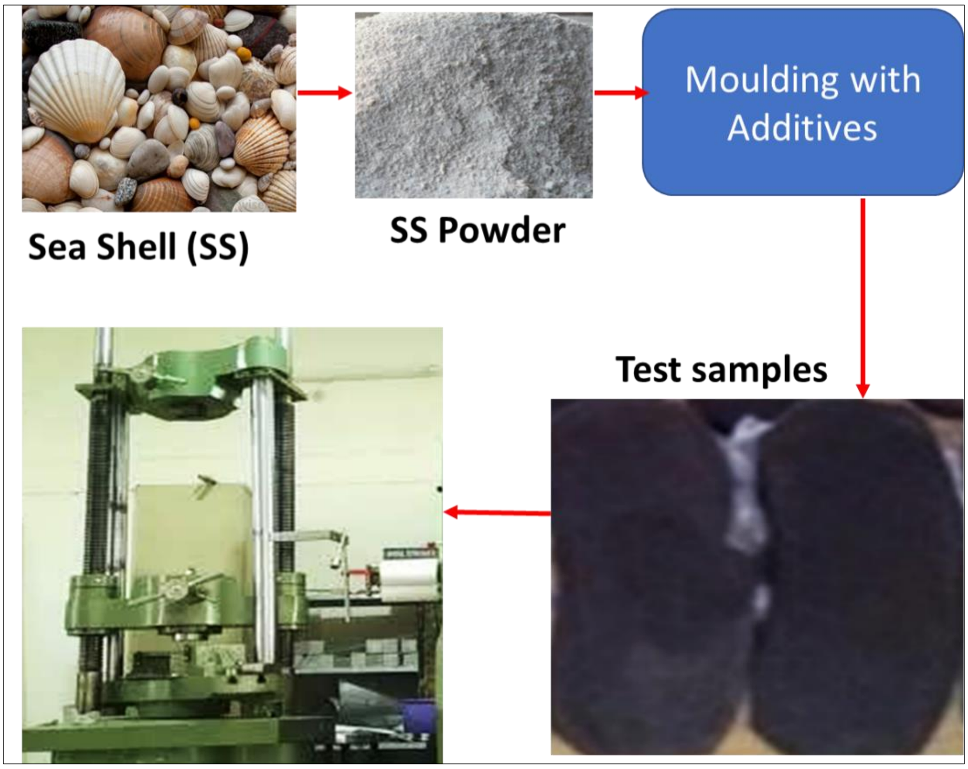

Figure 1. Formulation of samples for tests

To further remove moisture from the shells, oven drying at above 100°C for 5 h was used. To facilitate grinding, the dry shells were broken into tiny pieces using a hammer. Following that, the decreased sizes were ground in a clean grinding machine and sieved into various mesh sizes. Particles with a diameter of 125μm were collected and kept, whereas particles with a diameter of less than 125μm were removed.

2.1. Preparation

Each sample weighed approximately one kilogramme and was prepared using the components listed in Table 1. The samples were weighed using a KERRO digital weighing scale (model no. BL 3002) with a maximum capacity of 300g. The measured and applied polyamides resin to a plastic container, followed by filling components and thoroughly mixing. Finally, the reinforcing material(s) was/were added, and the mixture was well mixed. After adding the accelerator and catalyst, the composites were exposed to sunlight to cure. The filler ingredients used in the samples were consistent throughout their preparation [13]. However, at a 5% interval, the matrix and reinforcing elements were changed by 20, 25, 30, and 35%. Initially, separate reinforcing materials were utilized to manufacture composite materials. Figure 1 illustrates several formulated samples for relevant tests.

Table 1. Formulation for sample preparation

ID	Materials (wt%)						
	SS	Resin	Catalyst	Accelerator	Graphite	Caronate	Metal chips
CS20	20	63	1	1	5	5	5
CS25	25	58	1	1	5	5	5
CS30	30	53	1	1	5	5	5
CS35	35	48	1	1	5	5	5

2.2. Characteristics of composites

Characterization was used to establish the appropriate composition of samples of the formed composite materials. Calculated the average values of three items with the same composition that were examined [14]. The densities of SS were determined using an estimated approach. The mass of the powders with a volume of 10 mL each was determined using a very sensitive weighing scale. Density was calculated by dividing the acquired mass by its volume. The operation was repeated five times, and the average density value was recorded. The following are the pertinent characterization tests performed on the materials:

2.2.1. Oil and water absorption test

This test provided information on the solvent-absorbing capacities of several materials. Weighed samples (I) were soaked in water in an enclosed system for 24 h and then reweighed (F). The percent water absorption was calculated using equation 1 [15]. Similar tests were conducted using a solvent-based engine oil (SAE 20/50).

$$A = \frac{F-I}{I} \quad (1)$$

Here, A referring to the absorption of oil or water.

2.2.2. Compressive strength

At room temperature, the Compressive strength test of the brake pad composites was performed using a universal testing machine (UTM) with a load capacity of 100 kN. Each sample had an initial cross-sectional size of 200 mm^2 and was firmly held by the UTM lock's bottom and upper cross members. A little load was first applied, then the load was steadily raised until the sample failed. The sample's Compressive strength was determined using the weight of the load at the time of failure [16].

2.2.3. Hardness test

To determine the composite's hardness, an indentation hardness test was performed using a direct durometer [17]. The hardness test was conducted by determining the composite's surface's relative resistance to indentation caused by an indenter with a given diameter and under a defined load.

2.2.4. Wear test

A pin on disc equipment was utilised to conduct the wear test. Both commercial and designed brake pads were submitted to identical tests under the same conditions. The produced samples served as the disc, while the wearing pin was made of hardened steel. Prior to loading on the device, the starting weight of the samples was determined using a weighing balance. Throughout the test, the coefficient of friction was measured evenly. The starting temperature was determined using an infrared thermometer. The apparatus's arm was loaded with a 100g weight and utilised as a normal force for the coefficient of friction determination. The test was allowed to run for half an hour, and the friction coefficient was calculated using equation 2 and wear rate by equation 3 [18].

$$\mu = \frac{F_r}{N} \quad (2)$$

$$Wear\ rate = \frac{F-I}{I}\ X\ 100 \quad (3)$$

where, μ is the friction coefficient, Fr is the frictional force in Newton, N is the normal force, F and I are the final and initial weight respectively.

3. Result and discussions

3.1. Densities of composites

The average density of SS reinforcing materials measured is 1.7 g/cm^3. This demonstrated that a small rise in densities was observed as reinforcing elements were added. Thus, SS powder is ideal for materials with a lower density, which is required for vehicle brake pads. This density value for SS was consistent with prior findings.

3.2. Oil and water absorption properties

Figure 2 depicts the results of a water absorption test done on four identical test materials. Suffixes A, B, C, and D indicate the percentages of SS and mixed materials (A) used to produce the composites at 20, 25, 30, and 35 weight percent, respectively. Water absorption findings shown in Figure 2 indicate that when the composition of the reinforcing powder changes, the amount of water absorbed by the samples increases proportionately [19]. The greatest water absorption percentage of 0.37 percent was achieved with those made utilising SS powder (Figure 2). As a result, the greater hydrophilic character of SS is confirmed in comparison to other materials [20].

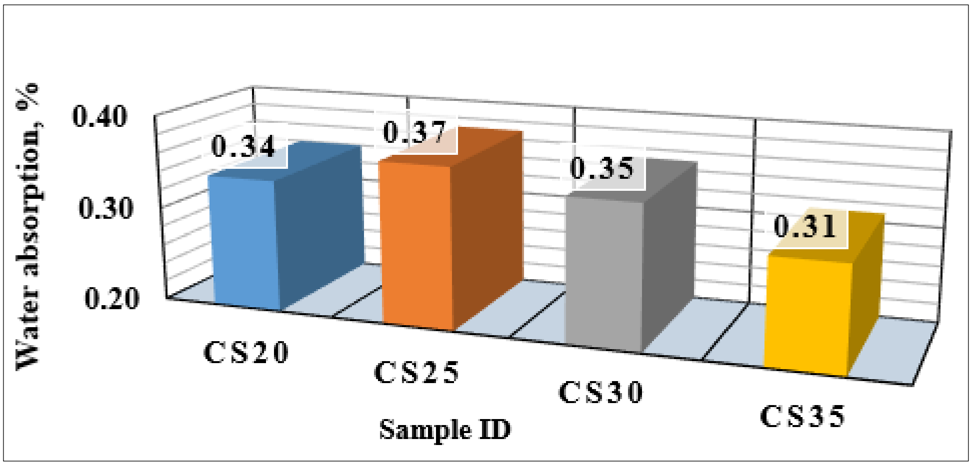

Figure 2. Samples water absorption tests

The results of the oil absorption test are shown in Figures 3. The observed patterns were comparable to those seen in the water absorption test. The oil properties were altered by the composites formed as a result of the weight combination of SS and other elements. The 25% weight composite was shown to absorb the most oil, followed by the other CS. Additionally, the results indicated that water had a greater absorption capacity than oil for the created composite material [21].

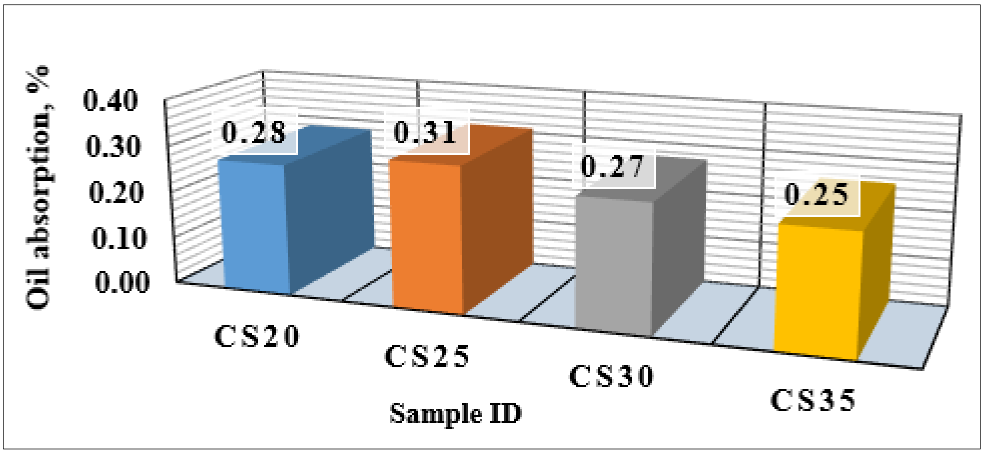

Figure 3. Samples oil absorption tests

3.3. Compressive strength

The average value of the compression test on three samples is depicted visually in Figures 4. The brake piston's pressure was determined by conducting a compressive strength test on the created composite materials. The compressive strength plots for each powder reinforced composite material showed similar patterns. A composition of around 25% was found to be optimal for the composite materials. Additionally, the results indicated that SS powder reinforced composites have the maximum compressive strength when compared to other materials (Figure 4). The acquired results correlates to prior studies.

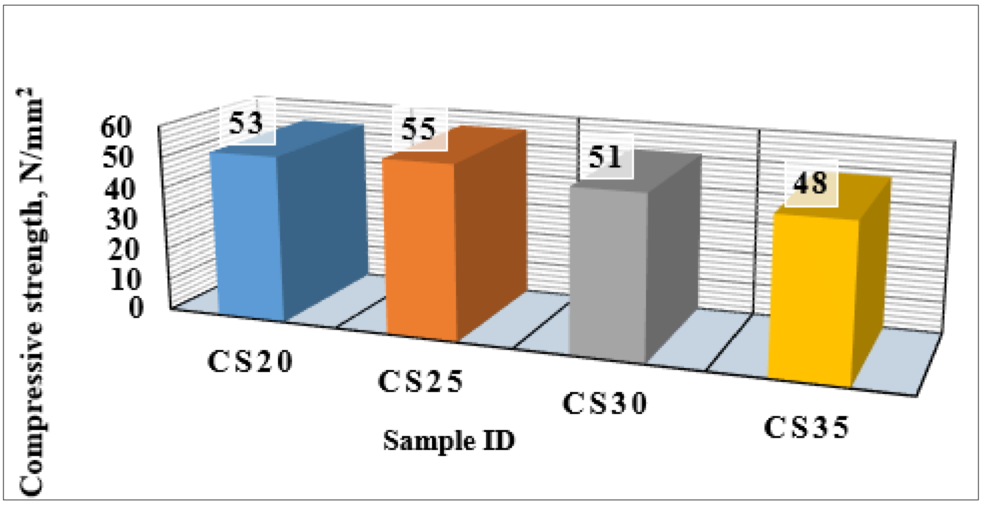

Figure 4. Samples compressive strength tests

3.4. Hardness properties

The results of hardness tests on three samples with identical compositions are given in Figures 5. The observed SS hardness values follow a pattern similar to those of compressive strength. This indicates that the lining materials with 35% reinforcement are the most optimum, since they provided the highest hardness in comparison to the other formulations.

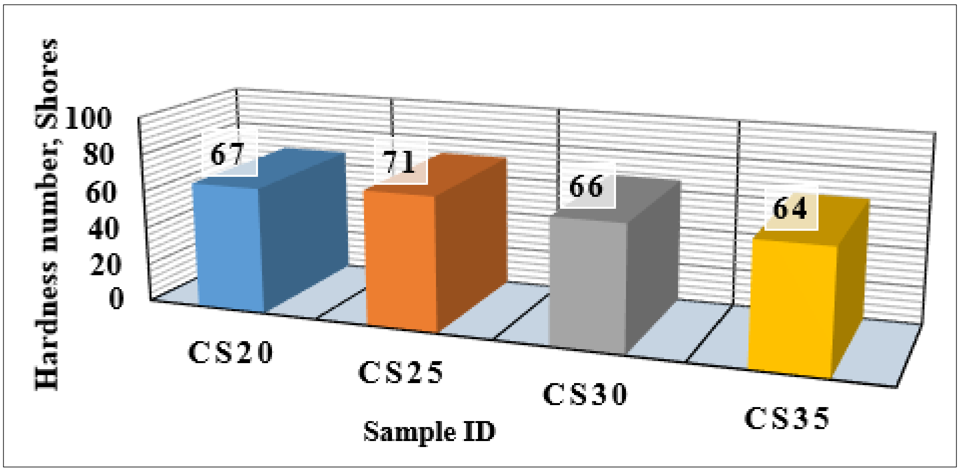

Figure 5. Samples hardness tests

Reinforcement percentages for SS formulations with maximal hardness are 20 and 25%, respectively. Additionally, the present maximum hardness values are consistent with those found in the literature [22].

3.5. Wear properties

The results of a test on the wear characteristics of three tests with the same composition are shown in Figure 6. During the wear test, properties such as temperature change and coefficient of friction were measured. The percent composition of reinforcing elements was found to enhance the coefficient of friction of the materials produced. Similar patterns were seen for all composite materials that had been developed. The friction coefficient values determined for the developed lining materials are equivalent to those published in the literature for bio waste-based brake lining materials [23].

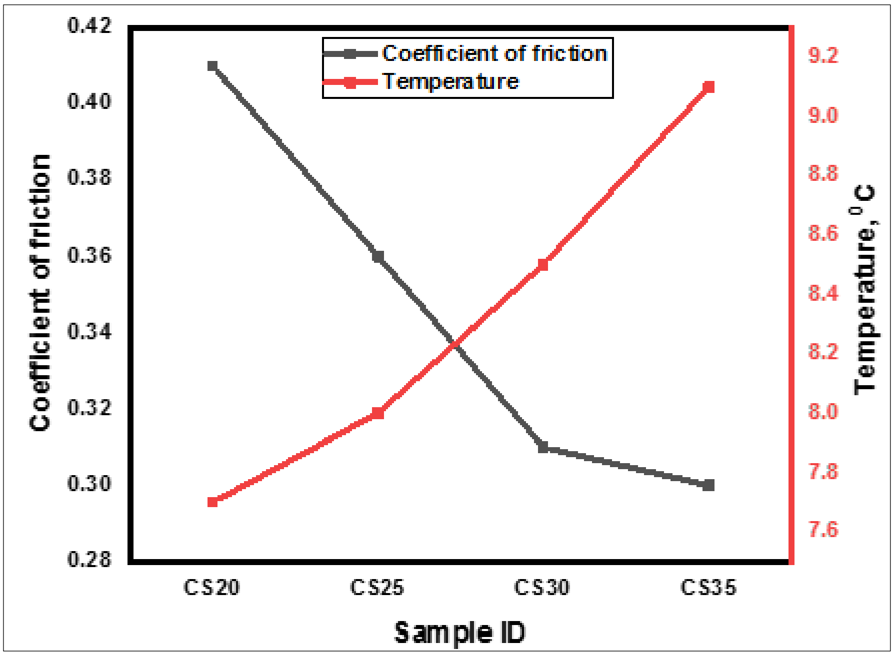

Figure 6. Samples coefficient of friction with temperature

They are, however, less than those of commercial brake lining materials. The highest friction coefficient of 0.41 was achieved for SS powder reinforced material, followed by 25 and 30%. The temperature change observed was proportional to the measured coefficient of friction for the weights examined. As a result, the value is anticipated to follow this pattern, as temperature change is proportional to the amount of friction generated between the two rubbing surfaces [24].

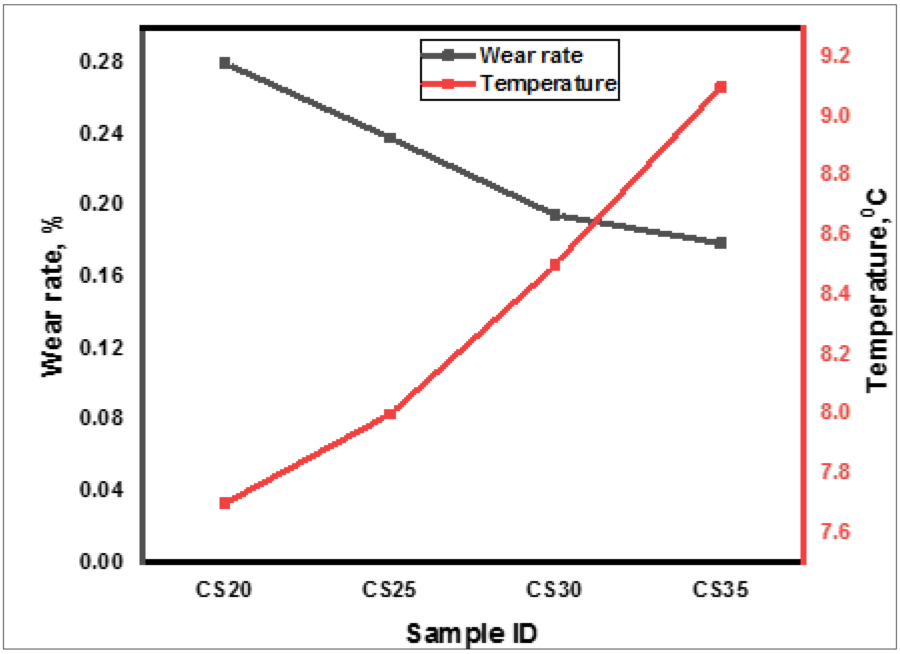

Figure 7. Samples coefficient of friction with temperature

Due to the usage of polyamides, the material created has a higher wear rate than commercial brake lining materials. This might be a result of the materials' formulas and contents varying. Further development of the proposed composite materials may make them a viable alternative to commercial brake lining materials containing asbestos.

4.Conclusions

SS powder, which is usually combined with other fillers, may be used to make brake lining material. Despite the notion that water absorption is greater than oil absorption, the sample's water and oil absorption increased when the composition of the reinforcing powder increased. When the reinforcing material was added, the compressive strength of the composites increased, reaching an optimal composition of 25%. Increasing the number of reinforcing components over the optimum value, on the other hand, reduced the composite's strength. The materials' hardness levels were similar to those reported in previous research. The friction coefficients measured for agricultural materials were also within permissible limits. They are, nevertheless, less costly than commercial brake lining materials. The new materials have a reduced wear rate than commercial brake lining materials due to material composition modifications. It is recommended that the produced materials be optimised in order to enhance their properties. To enhance the surface quality of the samples, metallic moulds may be employed.

References

1.BHALLA, K., GLEASON, K. Effects of vehicle safety design on road traffic deaths, injuries, and public health burden in the Latin American region: a modelling study. *The Lancet Global Health*, 8, 2020, e819-e828.

2.GAWANDE, S.H., BANAIT, A.S., BALASHOWRY, K. Study on wear analysis of substitute automotive brake pad materials. *Australian Journal of Mechanical Engineering*, 2020, 1-10.

3. GYIMAH, G.K., GUO, Z., HUANG, P., CHEN, D., 2017. Application of powder metallurgy methods for production of a novel cu-based composite frictional train brake material, in: Powder Metallurgy-Fundamentals and Case Studies. *IntechOpen*, 2017

4.ROBITSCHEK, D. From mechanical to regenerative Braking-Implications of the transition towards electric mobility on aspects of deceleration and tribological brake additives 2021, (PhD Thesis). Wien.

5.TEFERA, A. Design and Fabrication of Small Engine Driven Teff Harvesting Machine, 2020. (PhD Thesis).
6.EMMETT, E.A. Asbestos in High-Risk Communities: Public Health Implications. *International Journal of Environmental Research and Public Health,* 18, 2021, 1579
7.NAIDU, M., BACCHE, D., AVHAD, H., AKOLKAR, S., DHAGE, S., BHOSALE, A. An Insight on the Influence of Fiber Content on Plant Fiber Reinforced Brake Pads. *International Journal of Future Generation Communication and Networking*, 13, 2020, 1070-1082.
8.ABDULRAHMAN, A.S., AJANI, C.K., ALIYU, S.A. Production and characterization of asbestos-free brake lining material using agro wastes. *Engineering and Applied Science Research*, 48, 2021, 379-384.
9.RANGANATHAN, S., BOJAN, S.G. Tribological Behaviour of Carbon Fibre Reinforced Bio Degradable Material as an Alternative Frictional Brake Pad in Automobiles. *SAE Technical Paper*, 2020.
10.YASHWHANTH, S., MOHAN, M.M., ANANDHAN, R., SELVARAJ, S.K. Present knowledge and perspective on the role of natural fibers in the brake pad material. *Materials Today: Proceedings.*, 2021
11.ABUTU, J., LAWAL, S.A., NDALIMAN, M.B., LAFIA-ARAGA, R.A., ADEDIPE, O., CHOUDHURY, I.A. Production and characterization of brake pad developed from coconut shell reinforcement material using central composite design. *SN Applied Sciences,* 1, 2019, 1-16
12.SIVANAND, A., DEVANATHAN, C., SHANKAR, E., PRASANNAKUMAR. Wear Analysis of Epoxy Resin Composites Reinforced with Seashell, in: *Advances in Materials and Manufacturing Engineering. Springer*, 2021, 133-141.
13.SAHUQUILLO, O., KLYATSKINA, E., DUMANSKY, A., ALIMOV, M., SEGOVIA, F., SÁNCHEZ, A. In-plane shear tensile characteristics of polyester composites: Effects of sunlight exposition, *Materials Letters,* 302, 2021, 130370.
14.GEORGE, E.P., CURTIN, W.A., TASAN, C.C. High entropy alloys: A focused review of mechanical properties and deformation mechanisms. *Acta Materialia*, 188, 2020, 35-474.
15.RAMESH, M., DEEPA, C., SELVAN, M.T., RAJESHKUMAR, L., BALAJI, D., BHUVANESWARI, V. Mechanical and water absorption properties of Calotropis gigantea plant fibers reinforced polymer composites. *Materials Today: Proceedings*, 46, 2021, 3367-3372
16.UZOCHUKWU, M.I., UGBAJA, M.I., AIYEJAGBARA, M.O. Property investigation of cowhorn/ prewrinkle shell epoxy composite for automobile brake pad linings. *Journal of Emerging Trends in Engineering and Applied Sciences*, 10, 2019, 48-53.
17. SAINDANE, U.V., SONI, S., MENGHANI, J.V. Studies on mechanical properties of brake friction materials derived from carbon fibres reinforced polymer composite. *Materials Today: Proceedings,* 2021.
18.MINDIVAN, F., ÇOLAK, A. Tribo-material based on a UHMWPE/RGOC biocomposite for using in artificial joints. *Journal of Applied Polymer Science,* 138, 2021, 50768
19. NANA, A., KAZE, R.C., ALOMAYRI, T.S., ASSAEDI, H.S., DEUTOU, J.G.N., NGOUNE, J., TCHAKOUTE, H.K., KAMSEU, E., LEONELLI, C. Innovative porous ceramic matrices from inorganic polymer composites (IPCs): microstructure and mechanical properties. *Construction and Building Materials*, 273, 2021, 122032.
20.UDHAYASANKAR, R., KARTHIKEYAN, B., BALAJI, A. Coconut shell particles reinforced cardanol-formaldehyde resole resin biocomposites: Effect of treatment on thermal properties. *International Journal of Polymer Analysis and Characterization,* 23, 2018, 252-259.
21.ACHEBE, C.H., CHUKWUNEKE, J.L., ANENE, F.A., EWULONU, C.M. A retrofit for asbestos-based brake pad employing palm kernel fiber as the base filler material. *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications,* 233, 2019, 1906–1913.
22.KRISHNAN, G.S., BABU, L.G., KUMARAN, P., YOGANJANEYULU, G., RAJ, J.S. Investigation of Caryota urens fibers on physical, chemical, mechanical and tribological properties for brake pad applications. *Materials Research Express*, 7, 2019, 015310.

23.JEGANMOHAN, S., SUGOZU, B., KUMAR, M., SELVAM, D.R. Experimental investigation on the friction and wear characteristics of palm seed powder reinforced brake pad friction composites. *Journal of The Institution of Engineers (India): Series D*, 101, 2020, 61-69.
24.GHOSH, P., BANERJEE, S.S., KHASTGIR, D. Performance assessment of hybrid fibrous fillers on the tribological and thermo-mechanical behaviors of elastomer modified phenolic resin friction composite. *SN Applied Sciences*, 2, 2020, 1-14.

Manuscript received: 20.08.2021