Chapter 3

Fruit Peel Waste as a Sustainable Alternative in Brake Pad Production

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Abstract

A recent study investigated the use of waste from fruit peels in the manufacturing of brake pads as a possible asbestos-free alternative. The study used epoxy resin as a binder, with the amount increasing between 5 and 30 weight percent in 5 weight percent increments. Traditional asbestos-based brake pads were used as a reference in the study for the morphological, physical, and mechanical qualities of the studied brake pads. Increasing the amount of epoxy resin improved the compressive strength, specific gravity, and hardness of the brake pads while decreasing oil soak, water soak, wear rate, and percentage burnt. Additionally, the study found that brake pads made from lemon, orange, and pomegranate peel particles can also be used as an alternative to asbestos. The study highlights the potential of using fruit peel waste in brake pad production as a sustainable solution that offers a safer alternative to traditional brake pads. Further research is necessary to fully evaluate the long-term performance of these brake pads and their potential for commercialization.

Keywords: Brake pad, Fruit feel waste composites, Wear, Epoxy resin

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1. Introduction

The braking system is a vital component in vehicles, as it ensures the safety of passengers and other road users. The friction material used in the brakes plays a crucial role in determining the performance of the braking system. In the past, asbestos was used in brake pads, but its carcinogenic nature has led to the search for alternative materials. Currently, various materials such as metallic, semi-metallic, glass, aramid, carbon, and ceramic fibres are used as substitutes for asbestos in brake pads. Steel wool has recently emerged as a popular reinforcement material in asbestos-free brake pads due to its advantageous properties such as high strength and temperature resistance [1].

Brake pads are a component of disc brakes and consist of a steel backing plate with friction material attached to its surface. To maximize the performance and longevity of the brake pads, it is essential to maintain even wear on them. When the brakes are applied, the brake pads press against the disc brake rotors with the friction material, slowing and stopping the wheels. Over time, the friction material on the brake pads will wear out, and the pads will need to be replaced. Symptoms of worn-out brake pads include decreased braking efficiency and increased stopping distances.

2. Brake Pad Types

2.1 Semi-Metallic Brake Pads

These brake pads are made from metal materials, such as steel wool, wire, copper, and others, and typically consist of 30-65% metal. They are known for their durability, but can also lead to quicker wear on the brake rotors. Additionally, they may not perform well in cold temperatures.

2.2 Non-Asbestos Organic

These brake pads, referred to as NAO, consist primarily of organic materials, such as fiber, glass, rubber, and even Kevlar. They tend to produce less noise and are usually softer, but they wear faster and create more dust.

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2.3 Low-Metallic NAO

These brake pads are composed of an organic mixture with small amounts of copper or steel added to aid in heat transfer and improve braking. The added metal leads to the production of considerable brake dust and the pads can be noisy.

2.4 Ceramic Brake Pads

Made up mostly of ceramic fibers and other filler materials, ceramic brake pads are known for their cleanliness, low noise levels, and excellent braking performance. They are typically more expensive than other brake pad options, but they cause less wear on the brake rotors.

3. Functions of Brake Pads

Brake pads are the components of a vehicle that are responsible for transferring the vehicle's kinetic energy into thermal energy through the process of friction. They are comprised of two pads, each of which has a friction surface that is directed toward the rotor, and they are situated within the braking caliper. When the driver presses on the brake pedal, the caliper squeezes the two brake pads onto the rotor, which causes the car to either slow down or come to a complete stop. Heat is produced as the pad and rotor rub against one another, and this heat causes trace amounts of the friction material on the pad to be transferred onto the rotor. Because of this, a stickiness is created between the pad and the rotor, which provides the necessary friction to bring the vehicle to a stop [2-3].

4. Brake Pad Wear

Brake pad wear is a normal phenomenon that occurs as a result of the continuous friction between the brake pads and the brake rotors. Over time, the friction material on the brake pads will wear down, reducing their ability to generate the necessary friction to bring the vehicle to a stop. The rate of brake pad wear depends on several factors, including driving habits, vehicle weight, road conditions, and brake usage. Regular inspections of the brake system and replacement of worn brake pads are

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necessary to ensure the proper functioning of the braking system and the safety of the vehicle [4-5].

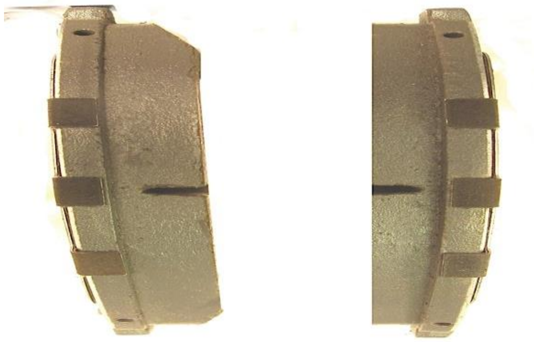

Figure 1. Even Wear

The brake pad wear patterns can indicate various problems with the braking system.

Even Wear: This means that each of the brake pads have the same amount of friction material, which is a sign that the brakes are working properly. To resolve this issue, you will need to service the caliper guide pins and slides in addition to replacing the brake pads and other hardware components such as abutment and anti-rattle clips.

Outer Pad Wear: The outboard brake pad has less friction material compared to the inboard brake pad. This is because the outer pad continues to rub against the rotor even after the caliper has released. This is caused by the fact that the outer pad continues to rub against the rotor even after the caliper has released. This could be the result of guide pins, bushings, or slides becoming frozen in place. To resolve this issue, the guide pins, bushings, or the complete caliper may need to be repaired or replaced, and the brake pads should also be changed.

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Inner Pad Wear: The inboard brake pad displays more wear compared to the outboard pad. This is caused by the caliper piston not returning to its rest position, which could be the result of a damaged seal, damage, or corrosion. There is also the possibility that there is an issue with the master cylinder. To solve this problem, you will need to follow the same procedures as when you fixed the problem with the outer pad wear. Additionally, you will need to inspect the hydraulic braking system and the caliper for damage to the guide pin hole or the piston boot. It is necessary to replace the pin holes as well as the piston boot if either has corroded or been damaged.

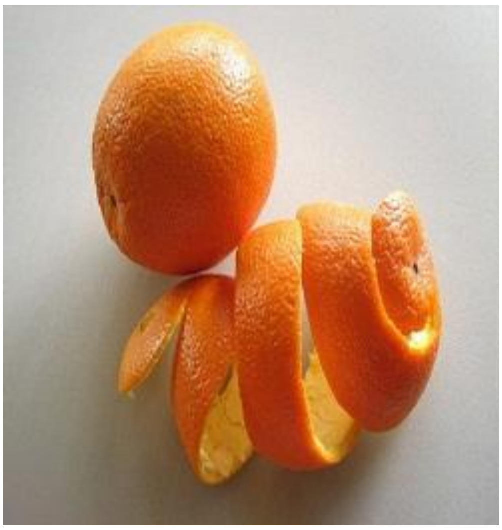

Figure 2. Orange Peels

Figure 3. Pomegranate Peels

The friction material wears away in a horizontal or vertical wedge pattern, which is caused by incorrect pad installation or guide pin wear. This type of pad wear is referred to as tapered pad wear. This can also take place if there is just one guiding pin or if the slide seizes. Follow the same procedures as described in the previous section to address the problem of outer pad wear. Damage to the Pads Such as Cracking, Glazing, or Lifted Edges: Because of misuse, an unsuitable break-in procedure, difficulties with the hydraulic system, seized caliper components, malfunctioning pads, or the parking brake not entirely retracting, the friction material has been physically destroyed. This can be caused by a number of factors, including: To fix this problem, you will need to replace the pads and then properly break them in. It's also possible that the parking brake has to be adjusted [6].

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Overlapping Friction Material The leading edge of the pad overlaps the leading edge of the rotor. This can be caused by wear on the guide pins, caliper, or caliper bracket; however, it can also be caused by using the incorrect rotor or pad for the vehicle. To resolve this issue, you will need to replace the pads and outfit the vehicle with rotors that meet the OE specification for diameter.

Uneven brake pad wear can affect the braking performance on the street, especially if the inner pad wears out completely. Tapered wear, both longitudinal and radial, increases the brake pedal travel and reduces the "feel" of the brakes and the response time. Because the piston in the caliper "cocks" and creates a larger room for fluid in the caliper, pedal travel increases, which results in a spongy pedal. This is because the fluid volume in the caliper increases. In addition, when the driver lets go of the brake pedal, the radial and longitudinal twisting moments disappear. This makes it possible for the caliper to realign itself to its position before the driver released the pedal. However, if the pad is worn at an angle, the rotor will force the pad and its piston further back into the caliper. This will result in the pad having to travel a greater distance in order to reach the rotor, leading to more fluid transfer and more pedal travel. This problem can be exacerbated by tapered pads and is also present even with flat pads due to the suspension parts being knocked around on rough road surfaces [7-8].

5. Materials and Method

A recent study evaluated the potential of using fruit peel waste, including banana, lemon, orange, and pomegranate, in brake pad production as a replacement for asbestos. The study investigated the effect of varying the amount of phenolic resin, a commonly used binder in brake pad production, from 5 to 30 wt% with an interval of 5 wt%. The morphological, physical, mechanical, and wear properties of the brake pads were analyzed and compared to traditional asbestos-based brake pads.

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The brake pads' compressive strength, hardness, and specific gravity were all improved when the amount of phenolic resin used was increased, while the oil absorbency, water absorbency, wear rate, and percentage of burned material were all reduced. The study also found that brake pads made from fruit peel particles, including lemon, orange, and pomegranate, can effectively replace asbestos [9-10].

This research highlights the potential of using fruit peel waste in brake pad production as a more sustainable and safer alternative to traditional asbestos-based brake pads. Further research is necessary to fully evaluate the long-term performance and commercial viability of these brake pads.

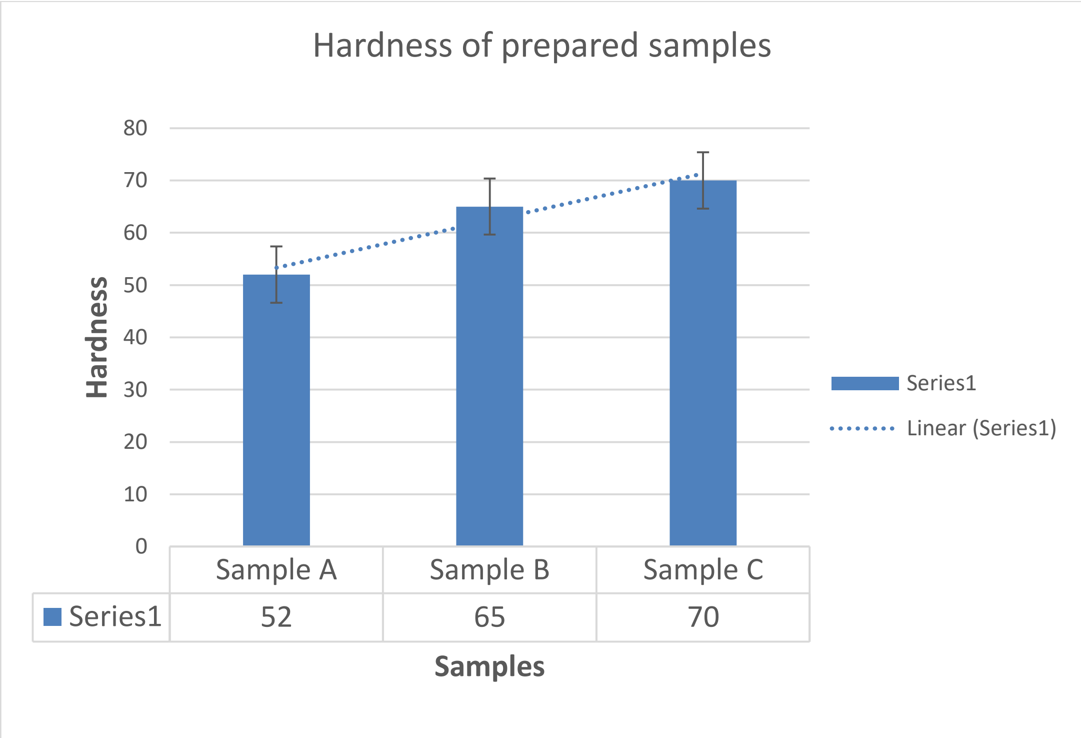

Figure 4. Hardness of prepared samples

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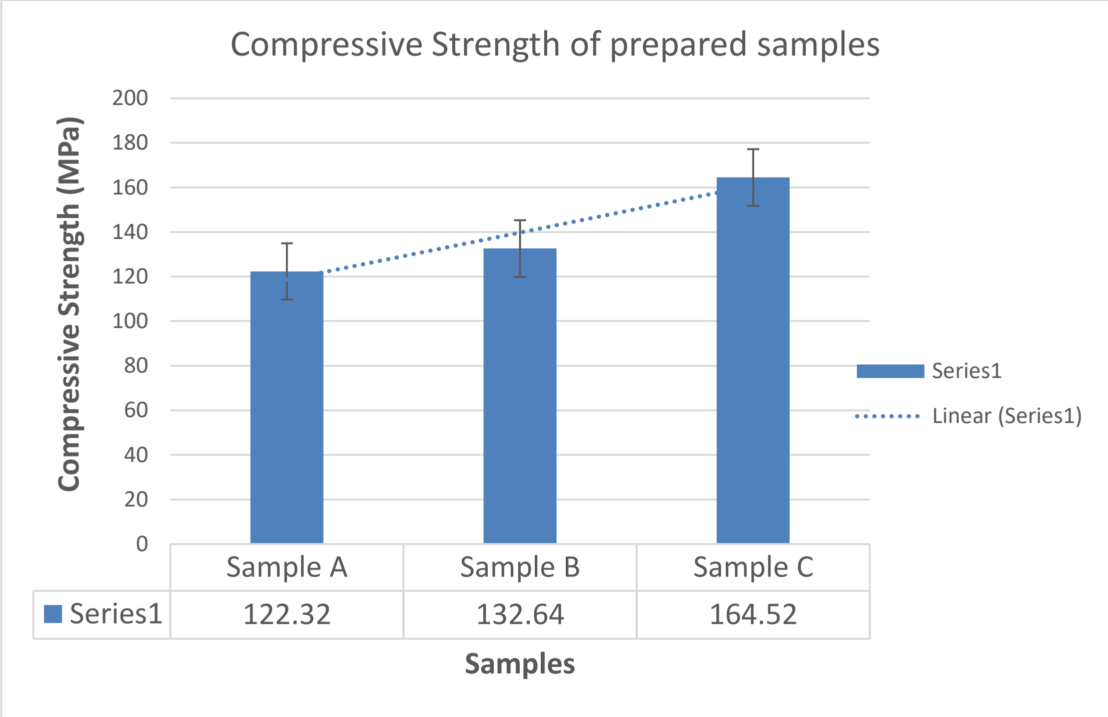

Figure 5. Compressive Strength of prepared samples

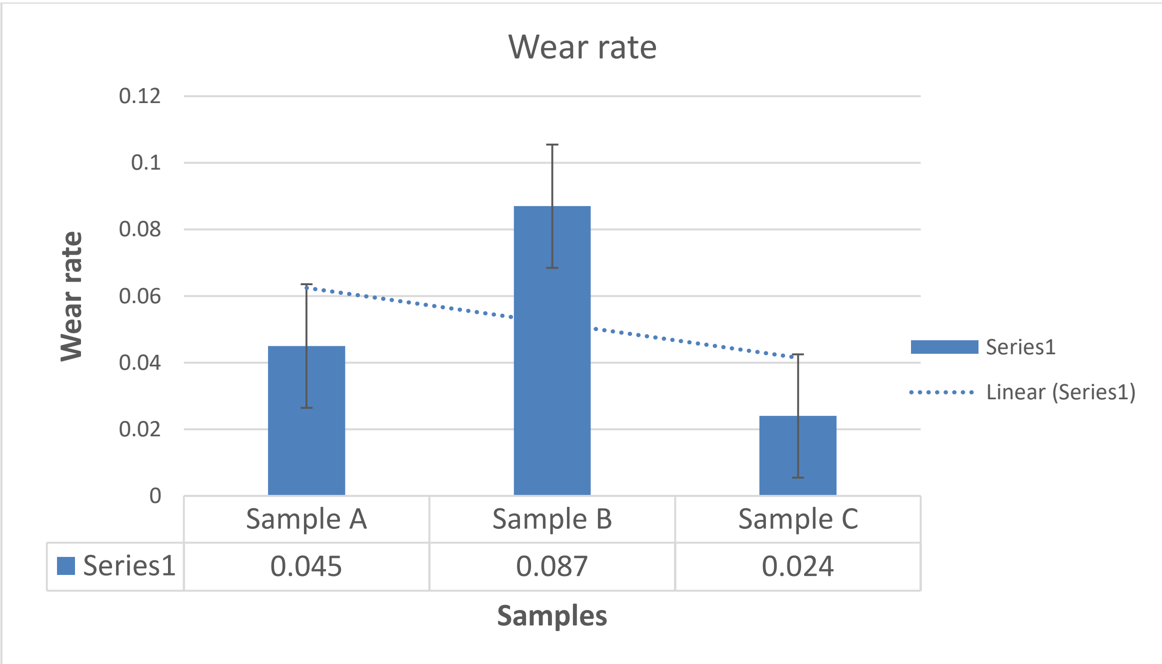

Figure 6. Wear rate Variation of prepared samples

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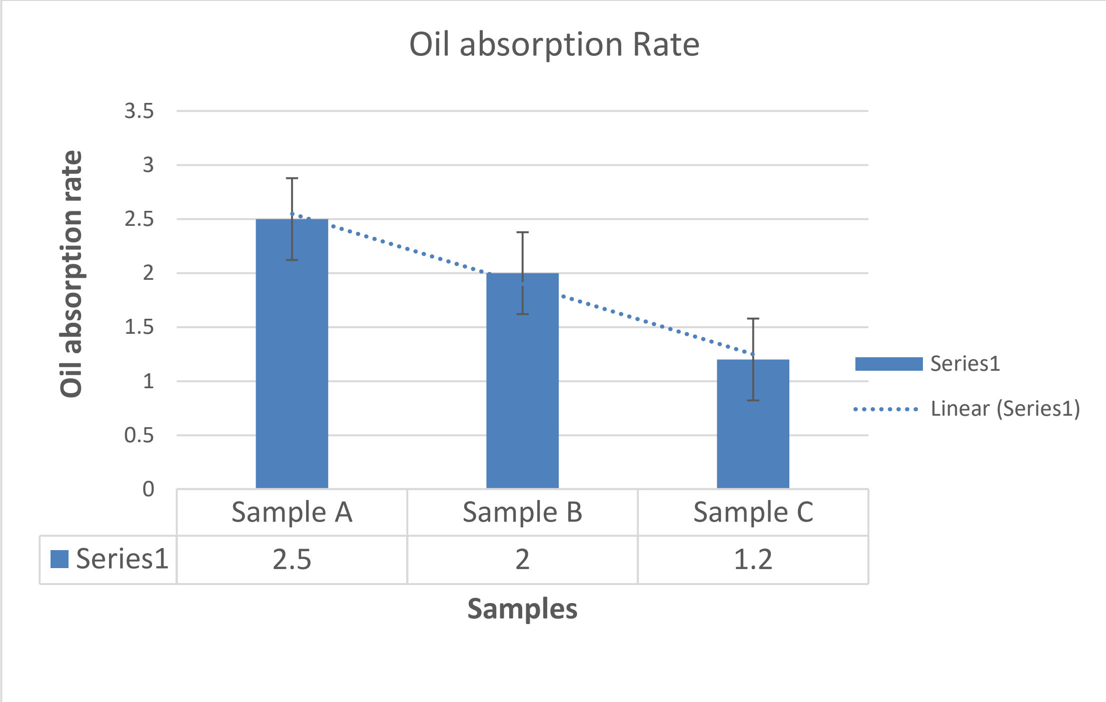

Figure 7. Oil absorption Rate of prepared samples

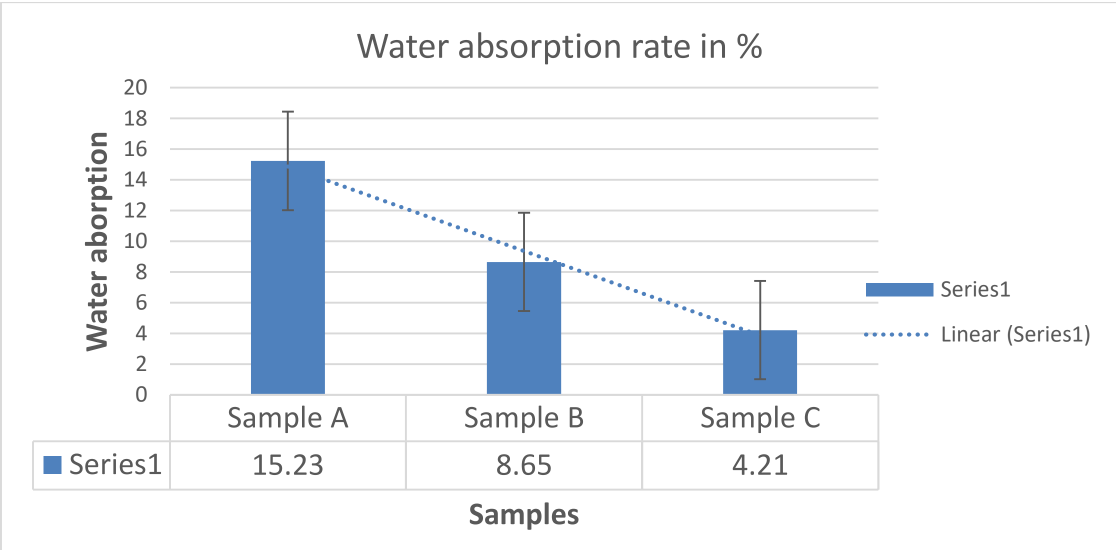

Figure 8. Water absorption rate in %

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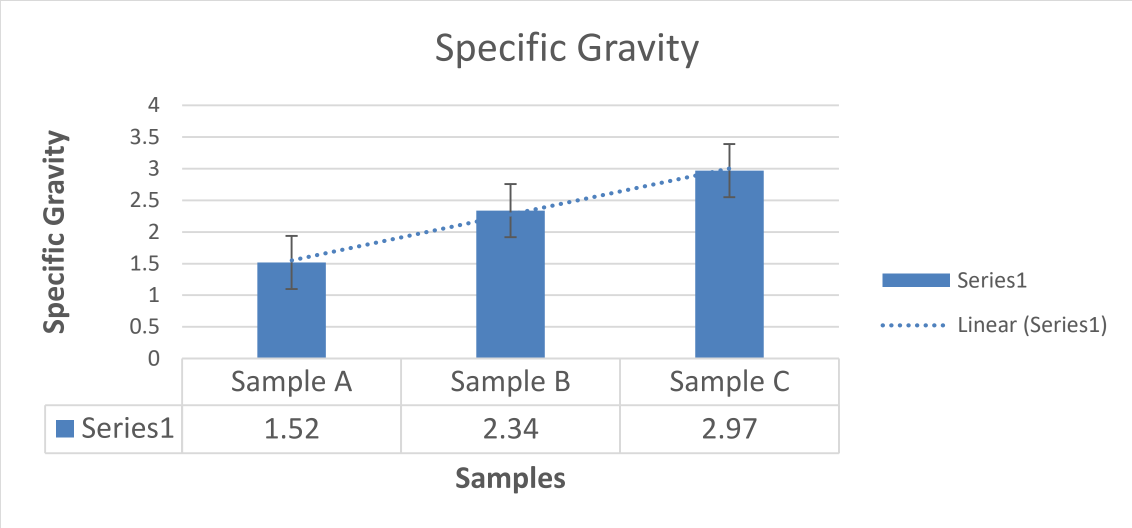

Figure 9. Specific Gravity of prepared samples

6. Conclusion

In conclusion, the evaluation of fruit peel waste in brake pad production provides a promising alternative to traditional asbestos-based brake pads. It demonstrates the potential for sustainable solutions in the automotive industry and the importance of exploring alternative materials to reduce waste and improve safety.

References

[1] Aigbodion, V.S., Akadike, U., Hassan, S.B., Asuke, F., and Agunsoye, J.O., "Development of asbestos-free brake pad using bagasse," Tribol. Ind., vol. 32, no. 1, pp. 45-50, 2010.

[2] Aigbodion, V.S., and Agunsoye, J.O., "Bagasse (Sugarcane waste): Non-Asbestos Free Brake Pad Materials," LAP Lambert Academic Publishing, Germany, ISBN 978-3-8433-8194-9, 2010.

[3] Blau, P.J., "Compositions, Functions, and Testing of Friction Brake Materials and their Additives," ORNL, being a report for the U.S. Dept. of Energy, 2001, http://www.ornl.gov/-webworks/cppr/y2001/rpt/112956.pdf, pp. 78-80.

[4] Bono, S.G., and Dekyrger, W.J., "Auto Technology, Theory and Service," DELMAR Publishers, New York, 2nd ed., 1990, pp. 45-48.

[5] Dagwa, I.M., and Ibhadode, A.O.A., "Determination of optimum manufacturing conditions for asbestos-free brake pad using taguchi method," Nigerian Journal of Engineering Research and Development, Basade Publishing Press Ondo, Nigeria, pp. 1-8, 2006.

ISBN 978-819620981-0

[6] Cho, M.H., Jang, H., Kim, S.J., and Kim, Y.C., "The effect of phenolic resin potassium titanate and CNSL on the tribological properties of brake friction materials," Wear, vol. 268, pp. 204-210, 2008.

[7] El-Tayeb, N.S.M., and Liew, K.W., "Effect of water spray on friction and wear behaviour of non-commercial and commercial brake pad materials," Journal of Materials Processing Technology, vol. 208, pp. 135-144, 2008.

[8] Bijwe, Jayashree, Kumar, Mukesh, Gurunath, P.V., Desplanques, Yannick, and Degallaix, G'erard, "Optimization of brass contents for best combination of tribo-performance and thermal conductivity of non-asbestos organic (NAO) friction composites," Wear, vol. 265, pp. 699-712, 2008.

[9] Kumar, Mukesh, and Bijwe, Jayashree, "NAO friction materials with various metal powders: Tribological evaluation on full-scale inertia dynamometer," Wear, vol. 269, pp. 826-837, 2010.

[10] Kukutschova, Jana, Roubiceka, Vaclav, Maslan, Miroslav, Jancik, Dalibor, Slovakc, Vaclav, Malachova, Katerina, Pavlickova, Zuzana, and Filip, Peter, "Wear performance and wear debris of semi-metallic automotive brake materials," Wear, vol. 268, pp. 86-93, 2010.

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