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FRICTION AND WEAR ANALYSIS OF BIO-COMPOSITE MATERIALS

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Abstract- In the braking system for the automobile and several other industries, brake pads are a significant spare part. The most frequent materials used in brake pads are asbestos, ceramics, and synthetic composites, which release hazardous particles into the environment that cause harm to flora and fauna. Due to asbestos' carcinogenic nature, bio brakes are becoming more and more well-liked on a global scale as an alternative to conventional brake pads. This resulted in the asbestos ban. Therefore, switching to candidate plant fibre instead of bio brakes can help reduce hazardous pollution. Specific behaviour and the impacts of each bio brake's unique properties and qualities should be researched in order to promote the use of bio brakes. These articles provide a summary of the findings about morphological and tribological qualities that can improve the effectiveness of bio brakes. Phenol formaldehyde has been researched while controlling hemp fibre.

Keywords- **asbestos; bio brakes; morphological and tribological qualities; carcinogenic**

I.INTRODUCTION

The usage of asbestos as braking materials has resulted in numerous environmental issues. According to a report by the World Health Organisation and environmental protection organisations, brake pad materials containing asbestos emit harmful fumes. Additionally, they are responsible for 21% of all emissions caused by vehicle traffic [1]. Particulate matter (PM) also has detrimental impacts on health and accelerates climate change. Previous research has also linked this pollutant to cardiovascular and respiratory conditions and classified it as carcinogenic [2]. The environment and human health may both be negatively impacted by brake pad emissions of ultrafine particulate matter. The respiratory and cardiovascular systems are known to be adversely affected by particles smaller than 2.5 m, which is known to have a substantial negative impact on human health. [3] Thus, asbestos was outlawed.

Because traditional reinforcement materials have the potential to be polluting, replacing metallic and mineral fibre with plant fibre might greatly minimise the emission of dangerous brake wear debris. Composite materials made of natural fibres are utilised to prevent environmental pollution. natural fibres are used in the development of brake pad composites as an alternative to traditional braking materials.

Numerous Scholar's Brake pad formulations have been documented by researchers up to this point [3]– [12] due to its non-exhaust particle matter. Bioproducts' natural fibres were used as a component to reduce environmental pollution. Because traditional brake pads are inherently polluting, bio-products are frequently used as filler materials. Natural fiber- based composite brake pads are employed because they are lightweight, non-toxic, biodegradable, environmentally friendly, and convenient to use. Numerous studies have proven that using plant fibres as reinforcement is feasible. This article compiles the observations and effects of the resin content on the morphological and tribological properties of the suggested brake pad composition.

II. MATERIALS AND METHODS

A. Material selection and its characterization

Hemp fibre was selected above other fibres like cotton, coconut, and others as a filler material for brake pads due to its high strength, chemical resilience, wide temperature range, quick growing rate, and beneficial cellulose supply. Additionally, compared to other fibres, it has better tensile, impact, hardness, flexural, water absorption, and wear properties [2],[20],[21],[24]. There have been numerous fruitful attempts to research various synthesis techniques for producing phenolic in a more useful and complex way [14]. The choice of

phenol formaldehyde as a binder was made possible by the substance's extraordinary adhesive properties, as well as its excellent dimensional stability at high temperatures, chemical stability, excellent mechanical strength, great durability, and high stiffness. It becomes clear that the most important elements that concurrently influence both mechanical and tribological qualities are structural integrity and ingredient adhesion. The precise quantity of plant fibres used as reinforcement enhances the performance of friction and wear [28], [33]. Hemp fibre was used to make bio-composite brake pad materials, together with phenol formaldehyde for the resin, barium sulphate, aluminium oxide, vermiculite for filler, and graphite for modifiers. While resin concentration varies, hemp fibre concentration is kept constant. In accordance, other filler materials are modified. NaOH was used to pre-treat the hemp fibre for 24 hours. After treatment, debris was removed from the fibre by washing it in distil water.

B. Fabrication of bio composite brake pad

NaOH was used to pre-treat the hemp fibre for 24 hours. After treatment, debris was removed from the fibre by washing it in distil water. To eliminate contaminants, the hemp fibre underwent a 24-hour pre-treatment with NaOH. After treatment, the fibre was cleaned with distillation water to get rid of dirt. In a mechanical blender for 15 minutes, the fibre was straightened, diced, and blended with various phenolic resin at varying contents while maintaining the consistency of the hemp fibre. Additionally, fillers and modifiers were included. In a compression moulding machine, this mixture was poured into a mould under a variety of pressure, temperature, and other conditions.3 curing times of 10 minutes each were provided. Five compositions with different phenolic resin contents were created.

Table 1 composition of various samples

By Mass→ By Weight↓	mp	PF	phitepowder	rmiculite	$_2O_3$	SO4
2	0.25X%	0.12X%	0.05X%	0.05X%	0.05X%	0.48%
4	0.25X%	0.14X%	0.05X%	0.05X%	0.05X%	0.46%
6	0.25X%	0.16X%	0.05X%	0.05X%	0.05X%	0.44%
8	0.25X%	0.18X%	0.05X%	0.05X%	0.05X%	0.42%
C22	5X%	2X%	5X%	5X%	5X%	8%

C. Characterization of bio composite brake pad

The physio-mechanical properties such as Density, Water Absorption, Ash Content, Compressive Strength, Impact Strength, Flexural Strength, Hardness was achieved. C22 being most efficient sample. They were tested and verified using ASTM testing methods. The types of ingredients, optimisation of the proportion of ingredients, and sintering technology parameters for the tested composites materials are crucial for obtaining higher physical, mechanical, and tribological characteristics. For the tested friction materials, the friction coefficients were stabilised over time, at the values suggested by the literature.

D. Tribological and morphological approach

The composition of an asbestos-free brake pad was determined utilising the TAGUCHI method of optimisation using MINITAB software. [18]. As a result of optimization output,25 various composition was obtained. The produced specimens according to outputs were subjected to friction assessment and screening tests to evaluate their average friction coefficient in pin on disc arrangement. The signal-to-noise (S/N) ratio and "smaller-is-better," "larger-the-better," or "nominal-the-better" criteria are all very helpful components of the Taguchi technique for conducting experiments [19]. The following braking criteria have a major impact on brake-pad materials: load, sliding velocity and distance, surface conditions, etc. Five samples of each composition were examined with varying values for three parameters (contact pressure, sliding velocity, and cycles). ASTM D99 was strictly adhered.

E. Scanning Electron Microscopy

The morphology, or shape and size, in conjunction with the chemical composition of their constituents, especially those of the pads, can be studied in addition to the brake disc and pad investigations mentioned above to learn important information. Both the morphology and chemistry of the diverse pad constituents can be obtained by scanning electron microscopy (SEM), a powerful tool providing well-defined characterization. They can aid in a better understanding of the origin, nature, and size range of the worn that is being released. The friction and wear behaviours are complicatedly impacted by the braking conditions. With high temperature, braking pressure, and beginning braking speed, the wear rate accelerates quickly.

Through the convection and conduction of the brake contact surfaces, the heat generated by friction is dissipated. Data on the composition were obtained via SEM studies of the brake assembly under investigation. Predicting the chemistry, sizes, shapes, distribution, and, to some extent, proportions of the various pad constituents also aid in determining the degree of mechanical bonding at the disc and brake pad interface. These characteristics primarily regulate the brake system's operation and wear emissions.[17].

III. RESULT AND DISCUSSION

A. Specific Wear Rate

When the test results were analysed in terms of the brake disc's friction coefficient, wear rate, and temperature, sample C18 and C22 showed optimal results.

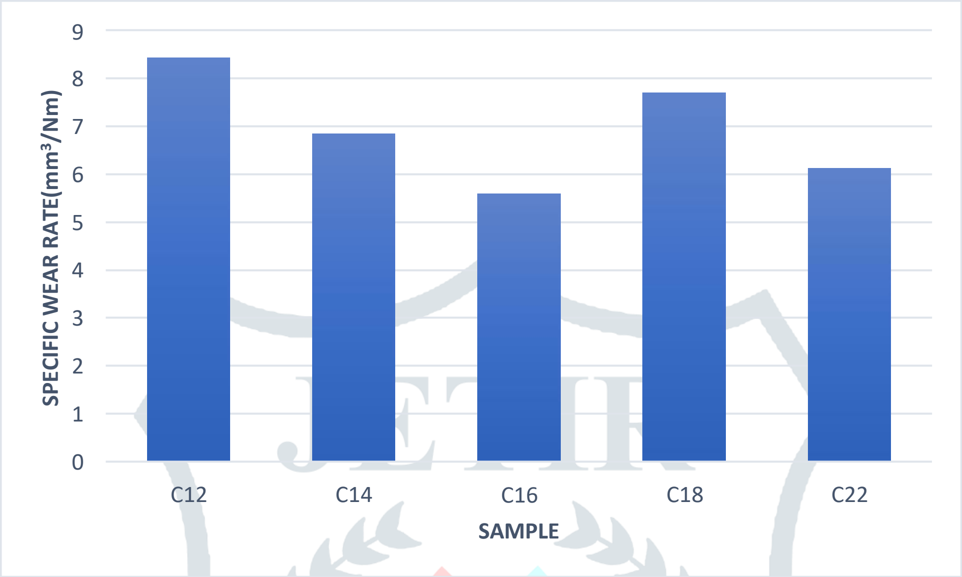

Figure 1 specific Wear Rate VS samples

Stronger brake pads were produced as a result of improved bonding caused by the higher resin concentration. The optimum wear rate is desired because smaller wear rates shorten the lifespan of brake pads and higher wear rates can harm rotors. C-18 and C-22 exhibit an optimal specific wear rate lever, making them suitable for use in light-weight vehicles.

B. Coefficient of Friction

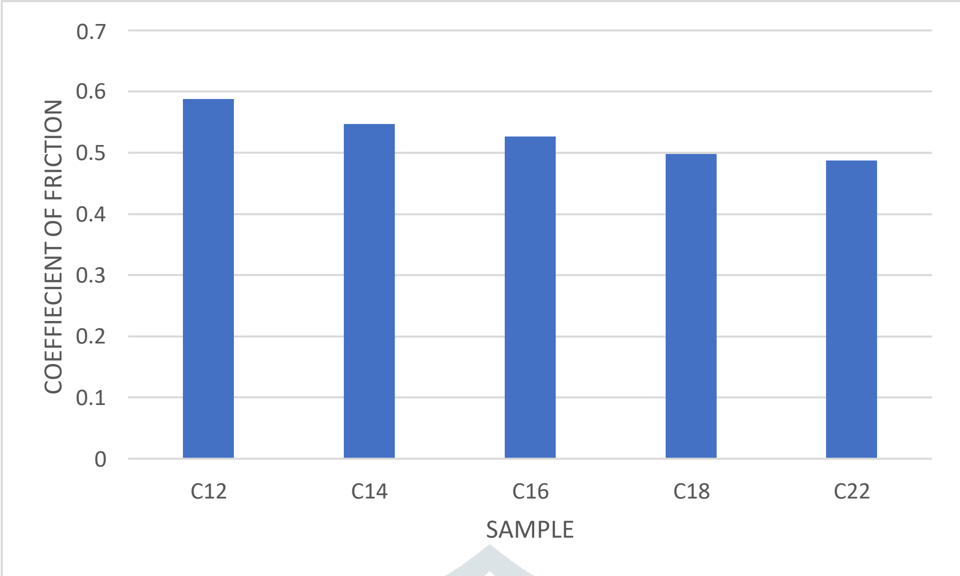

Figure 2 Coefficient of Friction

High and stable coefficient of frictions (COF) is desired during braking operation. [22] In order to modify COF in this bio composite brake pad material, graphite is employed as a filler. Materials with COF of smaller than 0.1 are considered as lubricous material Surface reference and material composition both affect COF. SAE standards specify COF values between 0.3 and 0.6. Although between 0.4 and 0.5 is the industry norm. In light motor vehicles, C-18 and C-22 have the perfect COF value, making them the best choice for brake pads, which was promptly accomplished.

C. SEM analysis

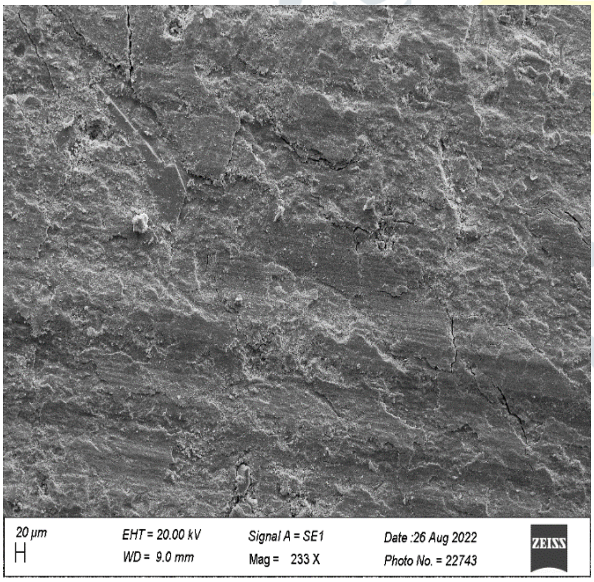

Figure 3) C-18

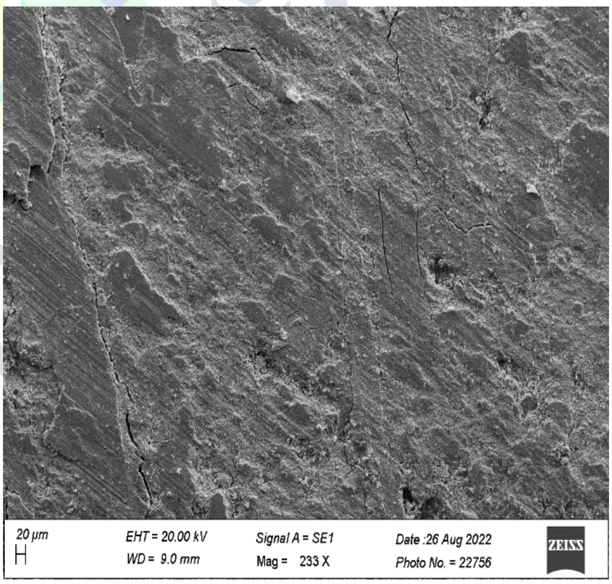

Figure 4) C-22

To learn more about the physical and chemical changes on the damaged surface, SEM experiments were conducted. The heat created during braking is better dissipated by graphite when used as a lubricant in the friction material in powder form. The frictional material will gain thermal stability from the barium sulphate. The brake pad's thermoplastic polymer resins produce a layer that spreads across the metal of the mating face, improving the materials' wear and frictional performance. Microcracks and wear debris are also created. The transfer layer can be seen in the images above for comparison. Several pictures were taken at various magnifications. All these wear types were proven in the current work's surface study and SEM observations investigation results on the contact surface of the actualbrake pad.

IV. CONCLUSION

When the test results were analysed in terms of the brake disc's friction coefficient, wear rate, and temperature, sample C18 and C22 showed optimal results. In this work, successful tribological and morphological properties of composite fibre brake pad material that has been manufactured using with hemp fibre as green material to replace asbestos. COF values between 0.4-0.5 makes it applicable as per SAE standards. SEM helps us to analyse the debris, microcracks, plateaus and linings. Proper visualisation of worn-out surface shows less debris which proves lower COF. The results of the surface studying, SEM observations investigation confirmed all these wear modes on the contact surface of the real brake pad.

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