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EXPERIMENTAL INVESTIGATION OF BIO-COMPOSITE FRICTION MATERIAL

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Abstract- Braking is a mechanical process that is dynamic and is influenced by a variety of circumstances. As an extension of it, the idea of bio-brakes has become more and more well-liked recently. A source of debate has always been how to replace the potentially harmful component in commercial and traditional brake pads while keeping comparable mechanical and tribological qualities. Natural plant fibers can be utilized as reinforcement instead of mineral and metal fibers, which can greatly lower the concentration of harmful chemicals and metallic components in brake wear debris. Many earlier investigations have suggested materials that utilize plant fibers as reinforcement for their total decomposition after use. Despite having good mechanical and thermal properties brake pads lose their thermal characteristics when temperature rises. This paper summarizes the observations and characterization of a brake pad by analysing physio-mechanical and thermal stability.

Keywords- **Bio-brakes, Hemp Fiber, Thermal Properties, Mechanical Properties, Physical properties**

I. INTRODUCTION

Since 1979, asbestos has been prohibited in many nations due to the fact that it causes cancer. The primary component utilised in traditional brake pads was asbestos. Since asbestos is no longer legal, researchers and academics must find a replacement that will benefit the environment and the automotive industry[2]. New generation brake pads were created by adding metal fibre reinforcement to existing brake pads, but specialists have also noted that after use, these brake pads produce pollutants from sources other than exhaust[4].These sorts of conventional brake pad material and metal reinforced material should be replaced with other non-polluting fibre brake pads in order to prevent environmental pollution[5]-[11].This lacuna initiated main challenge to the researchers to making brake pads with natural fibers by using various resin content.

Due to its non-exhaust particle matter, many scholar's brake pad formulations have been documented by researchers up to this point [3]–[12]. Natural fibres from bio-products were employed as ingredients to lessen environmental pollution. Bio-products are typically employed as filler materials. Since traditional brake pads are inherently polluting, hazardous brake wear debris can be reduced by replacing natural fibre with metallic and mineral fibre. Numerous investigations and research have demonstrated that natural fibre can be used as a brake reinforcement material. This paper summarizes the observations and characterization of a brake pad by analysing physio-mechanical and thermal testing's of the proposed brake pad composition.

II. MATERIALS AND METHODS

A. Material selection and its characterisation

Hemp fiber was chosen as an filler material for brake pad over other fibers like cotton, coconut, and others because of its high strength, chemical resistance, wide temperature range, rapid growth rate, and good source of cellulose. It also has higher tensile, impact, hardness, flexural, water absorption, and wear properties than other fibers[2],[20],[21],[24].

B. Combination of a material with phenolic resin at variable content

Phenolic resin is well known for its ability to bind a variety of substrates, .including paper, rubber, fibres, wood, glass, and metallic components[8]. Phenolic resins are a very popular type of polymer in the composites industry. Many successful attempts have been made to investigate various synthesis methods for generating phenolic in a more practical and sophisticated manner[13]. Academic researchers gives phenolic resins more attention, elevating them to a prestigious position among all thermoset resins. When it comes to applications that require structural stability and thermo-structural stability, phenolic resins are a very useful type of polymer in the composites industry[16]. Many researchers reported that phenolic resins are capable of fulfilling many desirable features, including exceptional mechanical strength, heat resistance, dimensional stability, as well as high resistance against various solvents, water, and acids[17].

Hemp fiber has been combined with phenolic resin at variable content by keeping Hemp fiber constant and have been treated with filler, modifiers, powdery ingredients. By using compression molding machine at various types of conditions like pressure, temperature and other things. The physio-mechanical properties such as Density, Ash Content, Water Absorption, Charpy Impact Strength, Flexural Strength, Young's Modulus, Tensile Strength, Hardness and Compressive Strength at Various standards ASTM D 792, ASTM D 5630, ASTM D 570, ASTM D 792, ISO 179, ISO 178, ASTM D 638, ISO 1586, ISO 604
respectively.

C. Composition of Hemp fiber with other ingredients at variable resin content

Hemp fiber is used as a filler reinforcement material and treated with others fillers, binders, modifiers, and other powdery ingredients to increase its strength which required for brake pad[20],[24],[26].

Table I:Composition of a Hemp fiber with ingredients

By Mass→ By Weight↓	Hemp	PF	Graphite powder	Vermiculite	Al_2O_3	$BaSO_4$
C12	0.25X%	0.12X%	0.05X%	0.05X%	0.05X%	0.48%
C14	0.25X%	0.14X%	0.05X%	0.05X%	0.05X%	0.46%
C16	0.25X%	0.16X%	0.05X%	0.05X%	0.05X%	0.44%
C18	0.25X%	0.18X%	0.05X%	0.05X%	0.05X%	0.42%
C22	0.25X%	0.22X%	0.05X%	0.05X%	0.05X%	0.38%

III. RESULTS AND DISCUSSIONS

A. Performance after Physical-Mechanical testings

The physio-mechanical properties such as Density, Ash Content, Water Absorption, Charpy Impact Strength, Flexural Strength, Young's Modulus, Tensile Strength, Hardness and Compressive Strength were calculated as shown in the Graphs below;

It has been determined that 6% NaOH treatment exhibits better qualities other than 4%, 5% treatments based on prior information from literature and other sources[2],[3].Hemp fibre has been treated with 6% aq. NaOH solution, and after being combined with other substances to create different compositions and the Physio-mechanical testings has been done.

Density- Due to the hand procedure employed to mix the fibres and the material was manually distributed using a grinder throughout the compression moulding process. the density of the composite fluctuated. $BaSO_4$ content was decreased by increasing the PF% and PF has a lower density than BaSO4, hence density of the material has been decrease. The less Density have been observed in C22 composite due to reduction in $BaSO_4$ because it have high density than others ingredients.

Ash Content- As per variation in compositions of brake pads according to resin content and other ingredients Ash content is varying thoroughly according to its proportion performance after the exhaust of the sample. The better Ash Content was found in C22 composite due to less proportion of $BaSO_4$ content.

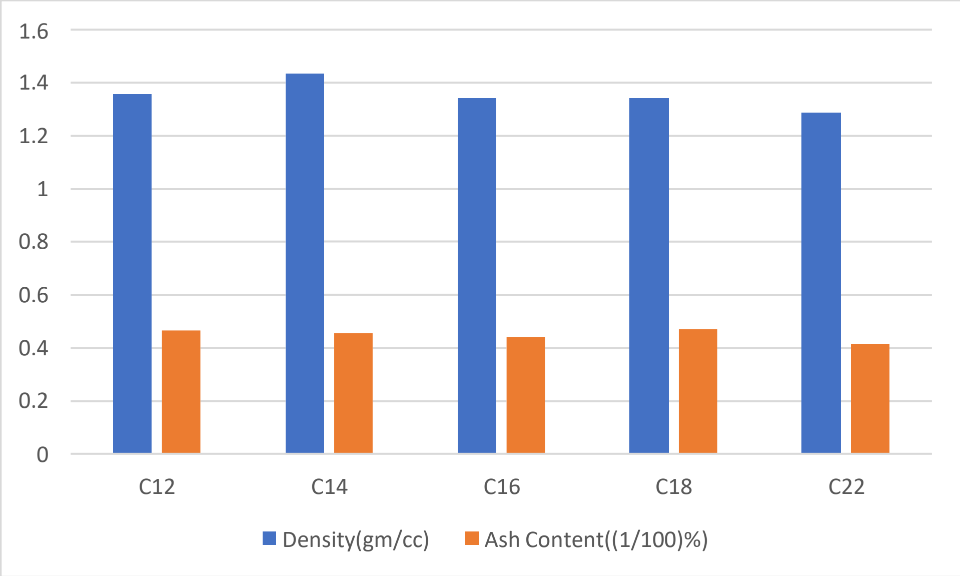

Fig. 1:Density and Ash Content results

Water absorption- Brake pads were cut using the water jet cutting process, but the water absorption in the brake pad caused the weakening of the pads [18]. The porosity tends to contribute to increased water absorption due to varied compositions and interactions between Hemp fibre, Resin, and other substances. when porosity increases and reduces in brake pads water absorption also get change according to brake pad porosity.

Charpy Impact Strength- A standard notched specimen's energy absorption during breaking under an impact load is measured by the Charpy impact test. Because PF has the ability to bind particles, the Charpy impact strength has varied with variations in PF content. The highest value for Charpy impact strength was found for C18 component.

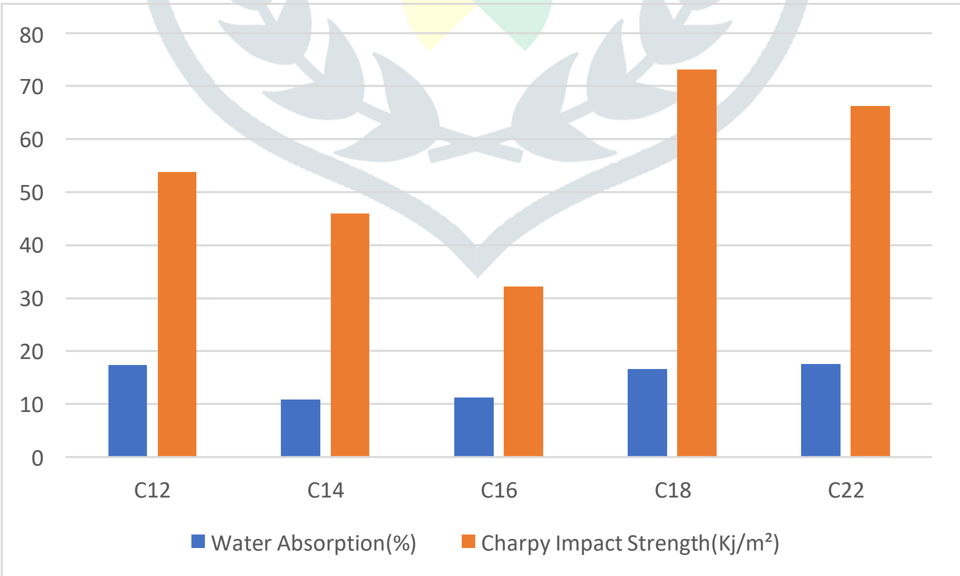

Fig.2:Water Absorption and Charpy Impact Strength result

Flexural Strength- Bend strength or flexural strength are other names for this property. It was accomplished by keeping one end fixed while applying a load to the central piece. It depends on how PF and BaSO4 interact because larger values of it were detected in the C14 and C16 components due to theirsimilar proportions in value.

Young's Modulus- It is a gauge of elasticity that is determined by the relationship between the stress placed on a material and the strain that results. The highest value was found in C12 component due to variation between PF content because PF act as a binder and when binder ingredient increases then elasticity of the material get decreases.

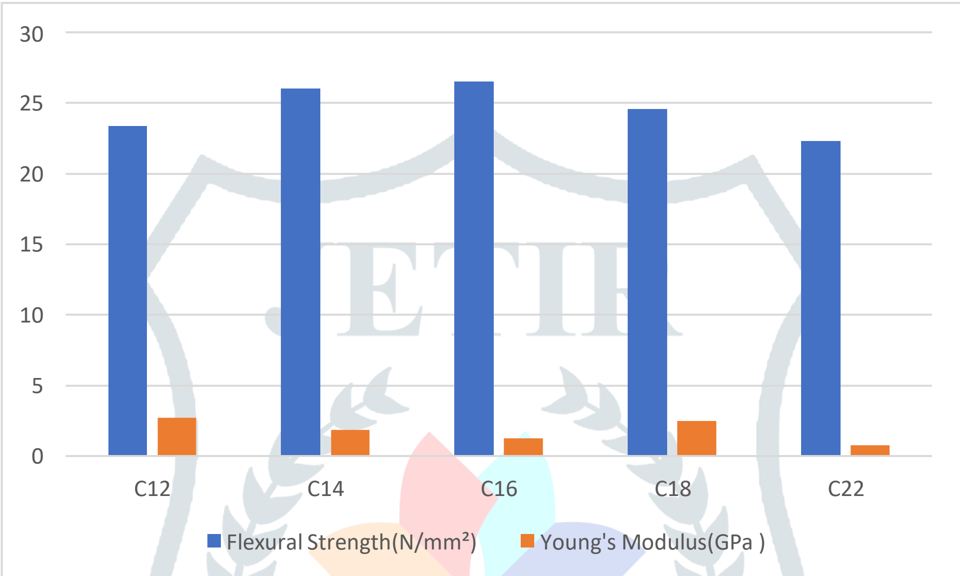

Fig. 3:Flexural Strength and Young's Modulus result

Tensile Strength- It is a material's resistance to breaking under tension. Due of the interaction between PF and BaSO4, the porosity and other constituents in a composition have an impact on the tensile strength. Due to less porosity between them, C12, C14, and C22 have the highest strength values.

Compressive Strength- The ability of a material to resist breaking when compressed. It is assumed that compressive strength is the same in all compositions since a filler and modifier elements that increase compressive strength are present in a constant proportion.

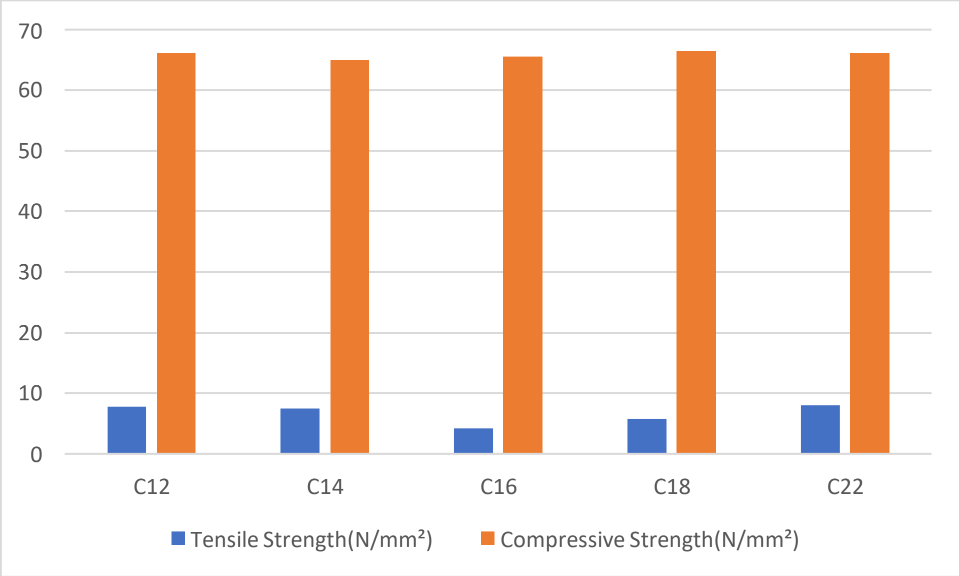

Fig.4: Tensile Strength and Compressive Strength result

Hardness- A material's capacity to fend off plastic deformation. From obtained results it is concluded that the hardness of the composition may be independent. Because the proportion ingredients which required for Hardness which have kept constant in all compositions.

B. Performance after Thermo-gravimetric analysis (TGA)

TGA of C18 and C22 samples was carried out in N2 atmosphere. The thermal degradation was observed in three stages at individual sample.

C18- Due to the deterioration of the moisture content in the fibres, the weight loss in the first stage [3%- 5%] begins close to the temperature of 300°C. At temperatures between 300 and 700 °C, second stage degradation is seen, which is attributed to the material's microstructural component. At this stage, there was a significant loss of between [28% and 35%].The third stage of degradation was seen at temperatures between 700 and 900 °C, and as a result, almost the same amount of weight was lost as in the second stage. This degradation is brought on by carbon fibre chain rupture. Because there is less phenol- formaldehyde (10%PF) in the second and third stages, there is more degradation because the fibres and matrix may have weaker bonds.

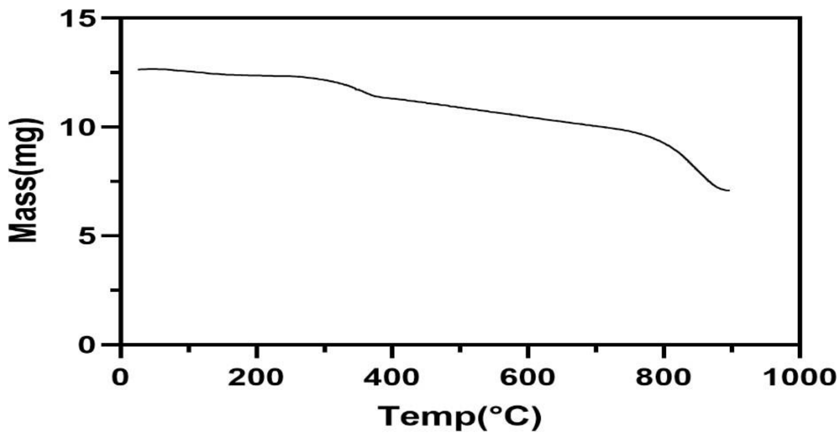

Fig.5 :TGA analysis of C18 component

C22- The weight loss in the first stage [3%-5%] is started near to the temperature 300° c first is due to the degradation of moisture contents in fibers. In second stage degradation is observed at 300-700° C, it was assigned to the degradation of the microstructural component of the material. The major loss was observed in this stage about [25% -33%].The third stage was observed in the temperature at 700-900° C and as a result, Approximately the same weight get lost as per the previous second stage, this degradation occurs due to degradation of carbon fiber chain rupture. The degradation in the second stage and the third stage have more degradation due to less wt.% (10%PF) of phenol-formaldehyde which may cause weak bondingin fibers and matrix.

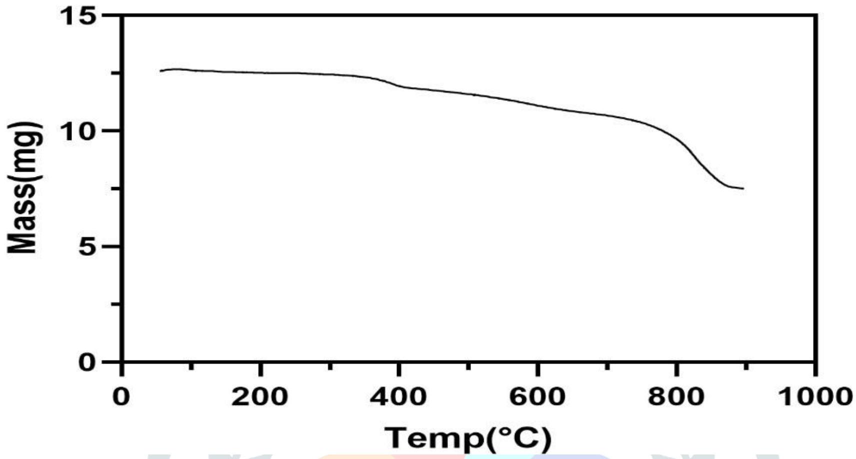

Fig. 5:TGA analysis of C22 component

III. CONCLUSION

From this investigation, it can be inferred that using the right quantity of PF and $BaSO_4$ content improves the physio-mechanical and thermal properties of brake pads. Mechanical and thermal qualities vary depending on the PF content. Although, due to its interaction with $BaSO_4$ concentration, it is challenging to make precise and accurate statements about fluctuation of PF resin content at the exact proportion. In the present study composition C22 as shown better performance in terms of physical, mechanical and thermal properties. According to this study, brake pads reinforced with hemp fibre have the potential to take the place of traditional reinforcement materials like metals and minerals brake pads. Even though, careful research is required to comprehend the precise behaviour and impact of Hemp fibre and PF contenton the physio-mechanical and thermal performance of the brake pad.

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