EXPERIMENTAL INVESTIGATIONS ON WEAR PROPERTIES OF NATURAL FIBRE COMPOSITES FOR BRAKE PAD APPLICATIONS

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Abstract - *The use of asbestos material is being avoided to manufacture the brake pads as it is harmful and toxic in nature. Further it leads to various health issues like asbestosis, mesothelioma and lung cancers. These brake pads can be replaced by natural fibres like Palm Fibres (0 to 50%) and Wheat (0 to 10%) with additives like aluminium oxide (5 to 20%) and graphite powder (10 to 35%). Phenolic resin of 35% is utilized as a binder. particulate wheat powder is used to reduce the wear rate. Aluminium oxide and graphite are abrasive in nature. This helps to make brake pads with high friction co-efficient and less wear rate with low noise pollution. The wear of the proposed composites has been investigated at different speeds. Various tests like wear on pin-on-disc apparatus, hardness on the Rockwell hardness apparatus and oil absorption test have been conducted. Phenolic resin produces good bonding nature to fibre. Thus, Fibres found to have performed palatably among all commercial brake pads. The objective of the research indicates that Palm fibre could be a conceivable alternative for asbestos in friction coating materials.*

Key Words: Friction materials, Palm fibre, Wheat, Brake pad, Wear test, Hardness test, Oil absorption test.

1. INTRODUCTION

Brake pad is one of the most important parts of braking system which is mounted on a brake disc rotor on each wheel. Braking system also contains many other parts like cylinders (master cylinders, wheel cylinders, tandem cylinders) and control system which may be operated by hydraulic system or pneumatic system. In different types of braking system varieties of materials are used for brake pads. Binders, fillers, friction modifiers and reinforcement are four important classes of ingredients into which they are often categorized. Asbestos is most frequently used brake pad material in which asbestos fibres are embedded in matrix of polymer along with other several ingredients.[2] Many research works have been carried out for the Asbestos free brake pad utilization of composite brake pad materials which provide more economical benefits and also preservation of environment.[8] To develop brake pad materials for the fulfilment of requirement many factors have to be considered like stable coefficient of friction and lower wear rate at different operating speed, pressure, temperature, environmental condition etc. For the fulfilment of above requirement, it is important of having appropriate Combination of materials and selection of materials is not an easy task rather it is complex process which require lot of experience. Due to carcinogenic nature of asbestos fibres use of asbestos fibres have been reduced day by day. [3-7]

Fig -1: Brake pad

The most important part of an automobile disk brake system is the brake pad. The brake pad serves as a component to decelerate the vehicle by converting the kinetic energy of the vehicle to heat energy through the friction occurring between the brake disc and the brake pad. The heat involved is dissipated into the surroundings. Some of the properties a brake pad should inhibit are:

a) They should be light in weight
b) They must be resistance to corrosion
c) They should produce low noise
d) They should have low wear rate
e) They should have a longer life and also be available at a reasonable cost.[8]

1.1 METHODOLOGY

The process for this study involved several important steps, starting with the Literature review: Technical paper, researches of composite materials Study and analysis of various types of natural fibers and their properties, Selection of natural fiber materials, 3-D Modeling of specimen of natural composite fiber, Preparation of making samples or specimen of various volume of fraction, Experimentally testing of specimen on wear testing machine, Analytically calculating the results of natural fiber, Calculating results with using ANSYS Software and Comparison of Analytical and ANSYS results for validation.

1.2 COMPOSITE MATERIALS

Table -1: Material of composite brake pad

Ingredients	Material	Description
Binder	Phenolic resin	common binder-Material weakness; if too much is used there is a friction drop-off at high temperature
Abrasive and lubricant	Graphite and Al2O3	Abrasive material for
Reinforcement fiber	Palm fibre, wheat fibre	Easily available and eco-friendly material
Additive and filler	Cashew dust	to use to reduce the cost

Above ingredients of material are used for making of composite brake pads. After that various volume of fraction of composition take for the making specimen and further experiments. [2-10]

2. EXPERIMENTATION AND TESTING

Materials:

Palm fibre and Wheat fibre were acquired from local industry. These collected fibres treated with sodium hydroxide and were ground into powder of required size. In the work Palm fibre of Palm Kernel that is particulates is mixed with aluminium oxide (Al2O3) powder and graphite powder in definite proportions is called as Type-1 composites and particulates Palm fibre mixed with powders of, Wheat, Aluminium and graphite in definite proportions is called as Type-2 composites. Phenolic resin was used as a matrix.

Alkali treatment:

The collected Palm fibre and Wheat fibres were suspended in a solution of caustic soda (NaOH) for one day to remove the remnant of red oil left after extraction. The fibre then watered to remove the caustic soda and is exposed to sun light for one week. The dehydrated fibres were ground into powder form of grain size of <100μm using a hammer mill.[8]

Composite preparation:

Palm fibre was base material, phenolic resin was binder material, aluminium oxide and graphite were abrasive and friction materials. Palm kernel and wheat fibres were collected from the waste palm oil fruit, rose stem and wheat plant respectively.[8] These collected fibres undergone for alkali treatment and then ground as a powder. The prepared powders of different fibres are mixed with particulate aluminium oxide and graphite as Type-1 and Type-2 composites in different volume fractions and are named as sample numbers like S1, S2, S3, S4 and S5 respectively. The hand lay-up method is implemented for the preparation of specimens having various sizes. Type-1 and Type-2 Composites with different volume fractions of the fibres are exhibited in Table 1 and Table 2 respectively.

Table -2: Composite material of Type-1 with different of volume of fraction

Sample No.	Palm Fiber (%)	Al2O3 (%)	Graphite (%)	Phenolic Resin (%)
1	10	20	35	35
2	20	15	30	35
3	30	10	25	35
4	40	5	20	35
5	50	5	10	35

Table -3: Composite material of Type-2 with different of volume of fraction

Sample No.	Palm Fibre (%)	Wheat (%)	Al2O3 (%)	Graphite (%)	Phenolic Resin (%)
1	5	5	20	35	35
2	10	10	15	30	35
3	15	15	10	25	35
4	20	20	5	20	35
5	25	25	5	10	35

2.1 CAD MODEL:

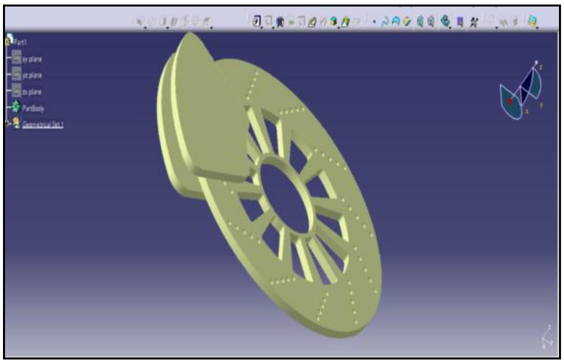

Fig -2: Actual Bake pad with disc

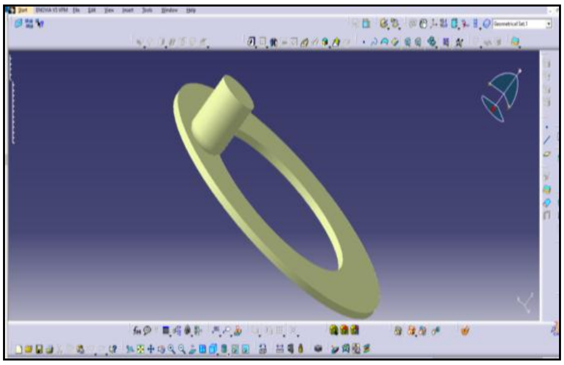

Fig -3: Test model of Bake pad with disc

Cad model is prepared in Catia v5 software.

2.1 EXPERIMENTAL PROCEDURE:

Pin on disc wear test is a known method for measuring friction and wear coefficients. This report attempts to define this test for obtaining the coefficients of friction and wear between cast iron disc and composite brake pad. Moreover, the worn mass obtained from this test will be used for validating the wear algorithm in the next section.

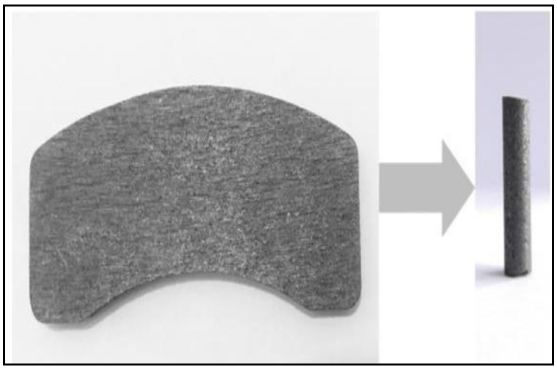

Fig -4: Original model of brake pad (left) and cutted pin for pin on disc test (right).

metallic brake pad, a standard specimen with a height of 22 mm and a diameter of 6 mm will be preparing. At Fig. 1.3, the cylindrical specimen and the original brake pad are displayed. Fig. 1.4 shows a schematic tribometer test setup, used in this work.

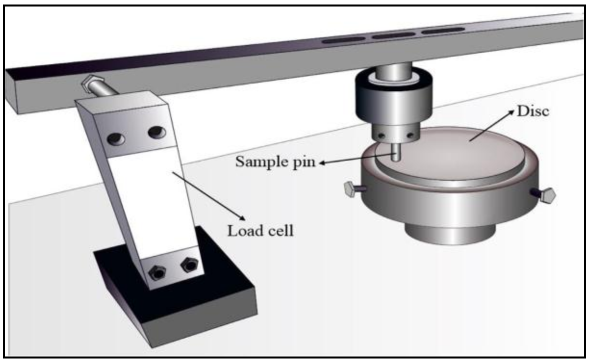

Fig -5: Pin on disc tribometer setup.

The Archard Equation,

The Archard Equation, which states that:

$W = K * s * P$ where,

K= wear coefficient

$P= F/A$ W= worn volume

S= sliding distance

P= Applied load, N

A= contact surface area of pin mm^3

2.2 EXPERIMENTAL RESULTS AND CALCULATION:

Here, we are testing the existing material Wear analysis. Metallic brake pad material:

Table -4: Test condition of wear analysis of metallic brake pad

TEST CONDITIONS	
Test parameter	**Value description**
Vertical force	10 N
Sliding distance	1000 m
Disc material	DIN 1.2080 steel

Pin material (Metallic Brake Pad)	Steel fiber, Phenolic resin, Carbonaceous lubricants, Graphite, Copper fiber, Brass fiber, Metal powder (iron), Reground rubber tread dust, Aluminum oxide, Iron oxide
Pin length	22 mm
Pin Diameter	6 mm
Pin density	2940.3 Kg/m3
Initial mass of pin	3.23 g
Wear test time	3000 s
Disc rotational speed	160 rpm

Table -5: Test results of wear analysis of metallic brake pad

Test Result	Value
Mass of the specimen after test	3.22 g
Mean friction coefficient	0.298
worn mass	0.1 g

By Archard wear equation,

Friction coefficient: - 0.298

Wear coefficient (k) :- $3.4 \text{ x } 10^{-14} \; (\frac{1}{pa})$

2.3 SIMULATION ANAYSIS OF COMPOSITE BRAKE PAD MATERIAL:

Wear simulation of pin on disc test:

In this section, to validate the proposed algorithm, wear simulation of pin on disc test is carried out and the results are compared with the results of the experimental test. Geometry modelling is performed using ABAQUS software for both contacted members.

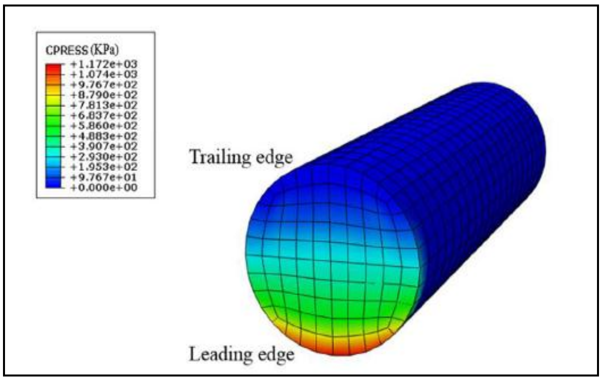

Fig -6: Press. Distribution of pin at the starting time of disc rotation

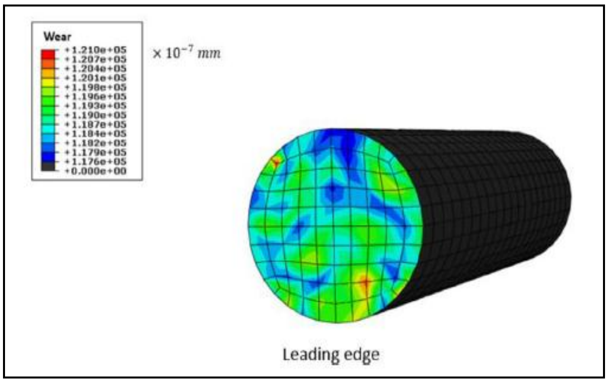

Fig -7: Wear contour in the last revolution of the disc

It is clear from Fig. 6 that the contact pressure at the leading edge is higher comparing to the trailing edge. It is because that the pin elastically bends a little, during the disc rotation due to the friction force applied to contact surface of the pin. Therefore, the contact pressure has higher value for the nodes closer to the leading edge comparing to trailing edge. In fact, after passing one or more increments of wear simulation, wear at the trailing edge will be started.

Wear contour for the pin after 3180 revolutions of disc is shown in Fig. 7 As can be seen, the trailing edge has the least wear which is due to lower contact pressure in this area. In the simulations, the sliding distance of the pin centre is about 1000 m which is the same as the performed test. The amount of worn mass after passing this distance is 98 mg.

3. RESULTS AND DISCUSSION

Comparing the experimental and analytical results of composite brake pad material. Which are shown in table

Table -6: Test results

	Experimental solution	FEA solution
Worn mass (mg)	100	98

Comparing experimental solution worn mass of composite brake pad material to FEA solution worn mass is little amount less. This result is for existing metallic brake pad material similarly natural composite fiber material testing will done.

4. CONCLUSION

Study the tribology behaviour of natural fibers in normal and hot conditions. These kinds of investigation will clarify the possibility of using natural fibers in friction composite. Percentage in brake pad composite and their capability to withstand at evaluating temperature. The agro waste might be efficiently used as a replacement for toxic ingredients in brake pad manufacturing when appropriately united with some other additives to fit a good performance of brake pad.

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REFERENCES

[1] D International Journal of Mechanical Engineering and Technology (IJMET) Volume 10, Issue 03, March 2019 BIOMASS-BASED COMPOSITES FOR BRAKE PADS: A REVIEW Oluwafemi E. Ige, Freddie L. Inambao and Gloria A. Adewumi Department of Mechanical Engineering School of Engineering, University of KwaZulu-Natal, Durban, South Africa.

[2] Eco- friendly composites for brake pads from agro waste Bushra Rashid, Universiti Putra Malaysia, Serdang, Selangor, Malaysia and Middle Technical University, Alzafaranya, Baghdad, Iraq Zulkiflle Leman, Mohammad Jawaid, and Mohamad R Ishak, Universiti Putra Malaysia, Serdang, Selangor, Malaysia.

[3] A review paper: Development of novel friction material for vehicle brake pad application to minimize environmental and health issues S.P. Jadhav a, S.H. Sawant b a Mechanical Engineering, D.O.T. Shivaji University, Kolhapur, Maharashtra, India b J.J. Magdum College of Engineering, Jaisingpur, Maharashtra, India.

[4] Compositions, Functions, and Testing of Friction Brake Materials and Their Additives Peter J. Blau August 200 1 Prepared for U.S. Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Transportation Technologies.

[5] Koya, OA, Fono, TR. Palm kernel shell in the manufacture of automotive brake pad, 2010 (accessed at www.rmrdctechnoexpo.com, 7/3/210).

[6] A Proposal for the Calculation of Wear John M. Thompson, PhD Consulting Engineer Mary Kathryn Thompson Mechanical Engineering Dept, MIT.

[7] Simulation and sensitivity analysis of wear on the automotive brake pad Amirhossein Hatam, Abolfazl Khalkhali Automotive Simulation and Optimal Design Research Laboratory, School of Automotive Engineering, Iran University of Science and Technology, Tehran, Iran.

[8] Pujari S, Srikiran S, Experimental investigations on wear properties of Palmkernel reinforced composites for brake pad applications, Defence Technology (2018).

[9] Physical, chemical and surface properties of wheat husk, rye husk and soft wood and their polypropylene composites Andrzej K. Bledzki a , Abdullah A. Mamun a,*, Jürgen Volk b a Institut für Werkstofftechnik, Kunststoff- und Recyclingtechnik, University of Kassel, Mönchebergstrasse 3, 34125 Kassel, Germany b IGV GmbH, Arthur-Scheunert-Allee 40/41, 14558 Nuthetal-OT Bergholz, Germany.

[10] Elemental analysis of brake pad using natural fibres s.sri karthikeyan[a],E.Balakrishnan[a],S.Meganathan[a]*,M.B alachander[a]A.Ponshanmugakumar[a] [a] Assistant Professor, Department of Mechanical Engineering, Sri Sairam Institute of Technology, Chennai-600044, Tamil Nadu, India.