Wear Behavior of Functionally Graded Automotive Brake Pad on Hybrid Composite

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ABSTRACT

The aim of this paper is to develop new organic composite functionally graded automotive brake pad is introduced. In this research work to improve the coefficient friction and wear resistance of brake pad by using functionally graded natural fibre and their brake additives. Coconut fibre is the one of the alternate research natural fibre, it is used for improving heat resistance and strength of the brake pad. Hence, coconut fibre has its own potential for use as filler in brake pads. Different laboratory formulations were prepared with varying coconut fibre, friction modifiers, abrasive material and solid lubricant using powder metallurgy technique. The pin on wear disc equipment is used to validate the responses for the prepared specimen. By the way of increase the coefficient of friction and wear resistance coconut fibre plays as the major role for the responses. Hence, natural coconut fibre is a potential candidate fibre for the automotive brake pad material.

Keyword: Brake pad – Coconut fibre – Coefficient of friction - Wear resistance

1. INTRODUCTION

Braking system is the major system in the vehicle. In this system, brake pad is an important vehicle component. In the past decade brake pads were made using asbestos material and it would be banned, due to some health risks and carcinogenic characteristics. At present the brake pads are classified into metallic, semi-metallic, new organic composite are commercially used as a brake pad material [1]. The inorganic filler is used to improve the manufacturability and also to reduce the cost. The reinforcing material is used to increase the mechanical strength of the friction material. The binder is used to maintain the structural integrity under thermal and mechanical stress. The abrasive materials are used to modify the friction coefficient, wear rates and it also improves the stopping performance. Additional property of brake pad is lubricants, which is used to counter the wear of abrasive and modify the friction coefficient [2].The main purpose of using this fibre is to improve the mechanical properties, as it is very strong and has good heat resistance. The reinforcing material is Aerosil which is using for reducing holes and also to improve the strength. The binder is Epoxy resin, that holds the powder and fibres etc., The abrasive material is alumina which is to improve the stopping performance. The lubricant is graphite which provide good friction coefficient and wear resistance [3]. Brake pads convert the kinetic energy to thermal energy by friction. The friction materials are required to provide a stable coefficient of friction and low wear rates at various operating speeds, pressure, temperature, and environmental condition [4]. Currently plenty of research focused on the potential of hemp fibre reinforced composites for the advantages of recoverable, environmental friendly, low cost, light weight, high specific mechanical performance, etc. These fibres performed fairly good mechanical
and friction properties than the mineral fibres, aramid fibres, etc. The brake pad was also done by using sisal fibre but it can’t be used to withstand high temperatures [5]. Here the hemp fibre influences to withstand high thermal resistance. The thermal conductivity of hemp fibre is 0.060 W/mK so it has high thermal resistance compared to other fibres [6]. The wear rates obtained from the produced brake pads could be attributed to the type of binder used and it is obvious that the epoxy resin used for the formulation of the pads provides a better bonding of the friction materials that resist wear rate. A similar system made of hemp fibres and epoxy resin to increase the tensile properties and reduce the porosity [7-10].

The aim of this paper is to develop new organic functional graded composite for automotive brake pads without any harmful effect. In this sense, few different laboratory formulations were prepared with varying coconut fibre, friction modifiers, abrasive material and solid lubricant using powder metallurgy technique. The tribological properties examined are coefficient of friction, wear resistance of the brake pad material. The new composites tested in the laboratory, modelling appropriate percentage ratio between matrix and reinforcement volume and can be obtained with better coefficient of friction and wear resistance due to higher mechanical properties, thermal stability, higher ability to hold the compressive force and without any harmful effect. These characteristics make them useful in automotive brake pad in current situation.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

Coconut fibre are extracted from naturally available epocarp of coconut and dried under room temperature to remove moisture. Then the extracted fibres were subjected to pretreatment with 5% of alkali solution NaOH for 1 hour and washed to remove the alkali content and then used for preparation of composite samples.

![Fig.1 Extracted Coconut Epocarp Fibre](image)

3. MECHANICAL DESIGN AND ANALYSIS

3.1 Chassis

The chassis was designed in NX 9 Modeling software and it was analyzed in ANSYS R15. The chassis was designed to take a static load of 20kg minimum. The Top part of chassis has lots of drilled holes which serves as holes for bolting other parts and reduce the weight of the chassis. The Holes are arranged in a zigzag linear arrangement so that the decrease in strength of chassis is not considerable. The flange which holds the motor was designed in a way that there is at least 10mm so that it can safely accommodate any bending due to loading above the designed value. The chassis incorporates mounting holes for both Ackermann steering and Differential steering system.
2.2 Sample Preparation

In this work, the fabricated functionally graded organic brake pad by using various composite materials. The organic brake pad comprises of fibre reinforcement, filler, lubricant, abrasive and binder. In this present work, coconut fibre acts as filler, graphite acts as lubricant, alumina acts as abrasive, epoxy resin acts as binder and aerosil acts as reinforcement. The formulated weight percentages of the materials were varied by means of trial and error basis method.

Table.2 Formulations of specimens in weight percentages

<table>
<thead>
<tr>
<th>S.N</th>
<th>Materials</th>
<th>Formulations of specimens in weight percentages (% wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S1</td>
</tr>
<tr>
<td>1</td>
<td>Coconut fibre</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Epoxy resin</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Graphite</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Alumina</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Aerosil</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

2.3 Preparation of brake pad plate

For each and every trial the formulated specimen (above mentioned materials wt%) were mixed and moulded. The hand layup mixture material was then compacted with a pressure of 20 MPa at 150° C using hydraulic hot press compression moulding machine and then after 30 minutes it was removed. After that plate was cured in 20 minutes at atmospheric air. The plate size is 350cm × 350cm and thickness is 3cm was prepared accordingly. Then these six plates can be taken prepared as per ASTM standard procedures for tribological test to find the coefficient of friction and wear resistant.

2.4 Testing procedure

The prepared six tribological tested sample can be tested by using pin on tester equipment. Both coefficient of friction and wear rate were noted by using this machine. At constant speed of 400 rpm at a time of 10 mins, disc can be rotate with radius of 200mm. load and speed were also adjusted for the test run. The output of the test sample can be digitalised during running of the machine, finally noted and calculated the responses.
3. RESULTS AND DISCUSSION

3.1 Coefficient of friction

The coefficient of friction of the functionally graded composite brake pad was based on the presence of frictional additives. The alumina and graphite are to increase the coefficient of friction in the brake pad composites. In order to provide and stabilise the required level of coefficient of friction with different operating conditions, while keeping the wear rate within the require limit. By the way of increasing the coefficient of friction, the stopping performance will increase. In this study, our objective is to reduce the stopping distance in the vehicle by increasing the friction coefficient. The results of coefficient of friction were increased gradually increased for all the six experimental runs by varying the load on tester as shown in graph. Among all the six experimental runs S1 sample formulation gives higher coefficient of friction of 0.45 micro meter. The S1 brake pad has 30 wt% of fibre, 40 wt% of resin, 10 wt% of other content will provide fine results. By further increasing the fibre percentage, coefficient of friction were decreased due to insufficient of resin content in the brake pad. The functionally graded composites coefficient of friction is 0.45 micro meter compare with standard asbestos of 0.4 micro meter.

![Coefficient of friction on load](image1)

Fig. 2 Pin on Disc Wear Test Machine

Fig. 3 Coefficient of friction on load
3.2 Wear Resistance

The wear rate of the brake pad was depends on the frictional additives and filler contents of the material. In this study, the frictional additives are alumina and graphite which are performed to reduce the wear rate. The hemp fibre is mainly reinforced with this composite material which gives low wear rate and also withstands high temperature resistance. Graphite powder is used in brake pad for good solid lubricant and stabilization of friction coefficient. Among all the six experimental runs S1 sample formulation gives lower wear rate of 0.0034 cm³. The S1 brake pad has 30 wt% of fibre, 40 wt% of resin, 10 wt% of other content will provide fine results. If below this weight percentage, the brake pad which are not giving the required responses. Since the wear rate and temperature resistance are mainly depends on the presence of fibre present in the brake pad. By testing process, wear rate was based on the load which are given to the tester. By varying the load, the wear rate can be reduced as shown in graph. By further increasing the fibre percentage, wear resistance were increased due to insufficient of resin content in the brake pad. The functionally graded composites wear rate is 0.0034 cm³ compare with standard asbestos of 0.0072 cm³.

![Fig.4 Wear resistance on load](image)

4. CONCLUSION

The evaluation of functionally graded composites brake pads developed from coconut fibre was determined and the conclusions are summarized as follows;

- Based on the wear and friction properties, this research indicated that coconut fibre composites can be used efficiently as an alternate composite.
- The weight percentages of composites are preferred to give high coefficient of friction and reduce the wear rate.
- The values of the wear rate and friction coefficient were obtained within the standard requirement for commercial brake pad, it will decrease the stopping distance performance of the vehicle.
- The hemp fibre has potential to suitable replacement of asbestos for brake pad production.
REFERENCES


