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Performance Analysis of Disc Brake Pad Material By Considering Friction & Wear As A Parameter

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***Abstract*- Automobile car braking system are to safety critical components whose performance and results depends strongly on contact conditions at the pad to disc interface. During braking both brake pad and disc surfaces wear out , affecting the useful life of braking system as well as its components & behavior. In literature, it is found that asbestos is widely used in automobile disc brake pads. But it is found that it may be to one danger disease called cancer to human being because of its carcinogenic nature. The main aim of this study is to analyze the effect of different material composition on friction & wear of brake pad. The Compo HC AF 693 is a Non asbestos friction material The phenolic resin is also added as a necessary ingredient to hold all the components together. NBR is a good toughened rubber has the organic binder and has a good positive effect or result to improve wear. The fillers barites, vermiculite are selected as fillers to enhance friction in the formulations. Synthetic graphite, Zirconium silicate is used as friction modifier because of their good wear resistant capability. The wear test is performed using pin on disk machine by varying the temperature sliding speed, applied load .The full factorial design of three are three-factors levels and analysis of due to change in variance is used in the study of the wear test**.

***Keywords*— Disc Brake, Braking, Brake Pad, Friction, wear, Full Factorial Design.**

I. INTRODUCTION

A vehicle braking system is a brake used to slow down a vehicle by conversion of kinetic energy into heat energy. The basic hydraulic system is mostly used in the main six stages. The brake pedal, and the brake boost (vacuum servo), master cylinder, the apportioning valves and finally the road wheel breaks themselves.

A braking system by means of artificial frictional components of resistance is applied to the moving machine & member, in order to stop the motion of a machine. In the process of performing this function, the brakes absorb heat given up by objects being lowered by hoists, elevators etc. The kinetic energy absorbed by brakes is dissipated in the form of heat energy. The heat is dissipated to the atmosphere and stop the vehicle, to the braking system should have following requirements:

- The brakes must be strong enough to stop the vehicle within a minimum braking distance or urgently applied brake.
- At time of driving the drive have successive proper control over the vehicle during braking and vehicle must not skid.
- The braking system must have well antifade characteristics due to long time use.
- The brakes should have good antiwear properties.

II. PROBLEM DEFINITION OF PROPOSED WORK

From the literature review it is observed that this combination of materials needs to be further studied. Accordingly to study it, following scope is defined. To obtain the defined the scope, the detailed methodology followed is explained in the section

Objectives

- To identify which factors affect the pad material, wear of brake and noise.
- To select the best pair material for brake disc and brake pad.
- To introduce a new alternative for NAO material for brake pad.
- To minimize the wear rate and increase the life of braking pad and disc rotor.
- Experimental verification of selected material at different temperatures.
- To determine significant parameter affecting wear and coefficient of friction.
- To reduce contact braking pressure, braking squeal, vibration.
- Study of worn surfaces of tested samples using SEM.
- Comparative study of developed composite material with commercial asbestos based brake pad material.

Steps Followed in Methodology:

The literature review of various research papers related to disc brake pad materials and their effect on friction & wear properties has been done.

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Then depending upon this literature review the proper material is to be selected. Then next step is to prepare the composite material of selected composition. After preparation of composite material, the specimens of the will be prepared. The experimentation will be done on the basis of Taguchi Array. The results of this experimentation will be analyzed. The specimens of existing brake pad materials are to be prepared and experimentation will be done. The samples of composite will be tested under SEM. The results will be validated by the comparison of developed composite material with existing. Then conclusions will be made depending upon the results.

Design Data required/ utilized in the Work:

Design of Experiment

Experiments are performed by investigators in all field. More normally, we can define an experiment as a test or series of test in which purposeful changes are made to the input variables of process or system .When a large number of experimental works have to be carried out when the number of process parameters increases. Experiments (DOE) is getting familiar in all over the world Experiments are used to study the performance of processes and systems which are affected by factors (variables). In order to find out relative importance of factors (that means which factor is more important or effective) we perform the experiments.

The objectives of the experiment are as follows:

1. To determine where to set the influential variables so that response is almost always near the desired nominal value.
2. To determine where to set the influential variables so that variability in response is small.
3. To determine where to set the influential variables so that the effects of the uncontrollable variables are minimized.

Applications of Design of Experiment

Experimental design is critically important tool in the engineering world for improving the performance of the process. Some applications of experimental design techniques are as under;

1. Choosing between Alternatives
2. Selecting the Key Factors affecting response
3. Maximizing/Minimizing a Response
4. Reducing Variation
5. Making a Process Robust

Advantages of DOE

DOE eliminates the 'confounding of effects' whereby the effects of design variables mixed up. The effects means we can't correlate product changes with product characteristics.

1. DOE helps us handle experimental error.
2. DOE helps us determine the important variables that need to be controlled.
3. DOE helps us find the unimportant variables that may not need to be controlled.
4. DOE helps us measure interactions, which is very important.

General Full Factorial Design

A design in which every setting of every factor. A design each level of one factor is combined with every level of all other factors. Full factorial designs have attractive statistical properties, and ensure that main effects along with certain interaction effects can be independently estimated. In the full factorial design all factors are taken into account and then running the experiment & then trying to get information of effects. A full factorial experiment involves carrying out at least one test one test at each possible combination of the levels of each factor.

The number of different combinations is found by raising the number of levels for each factor to the power of the number of factors studied. For example when studying two factors, each at two different levels there are $2^2 = 4$ such test combinations to consider. This is called 2^2 factorial designs. This is as stated above from above these values we have number of experiments as $2^n = 2^2 = 4$,

Which are as follows:

1. Both factors at a low level.
2. Factor A at low level and factor B at high level.
3. Factor A at high level and factor B at low level.
4. Both factors are at a high level.

The output Y (response) may have effect of factor A, factor B and Factor A Factor B.

Geometric representation of the 2^2 factorial designs

The 2^2 factorial experiments can be given simple geometric representation that takes the form of a square. Each corner of the square then represents one of the four unique tests defining the 2^2 factorial designs. Thus at the top right hand corner of the square represents test 4 where both the factors are set high. (-,-) represents the value for the output when all the factors are at their low level test 3, (-, +) represents the value for the output obtained when factor B alone is set at high its high level, test and (+, -) represents the value for output when factor A is at high level & factor B is at low level, test 2 .

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For full factorial design if number of parameters is large the number of experiments needed to capture all the effects maybe excessively large. For example a 10 factor 2 level experiments requires 2^{10} = 1024, runs to bring out all the interactions.

The main advantage of the full factorial design is it considers the all possible combinations for every factor at every level.

Variable Factors and Their Levels

A scientific approach to is most effectively. Full factorial design was taken as the basis for planning the experiments so that the appropriate data be collected which may be analyzed to obtain valid result and objective, analysis and conclusions.

Planning of experiments are developed in order to fulfill the following requirement:

- The whole controllable factors to be investigated.
- To get the all possible combination of factors and their levels.
- To establish a relationship between different input factors.

The following are basic steps, which are followed during the experiment.

- Selection of factor: The factors selected are feed rate and speed and drill diameter.
- Selection of the levels: The levels selected are 3 for three factors.

Selection of the Full factorial design: As factors having three levels are being taken, so the degree of freedom associated with one variable is 2 (No. of levels – 1). During experimentation all the trials were repeated three times, so for the 3^3 factorial total number of experiments performed are 27.

The ranges of the selected process factors were decided by the conducting experiments using one variable at-a-time approach. In total 27 runs, that is, in 27 experiments the level of each factor is repeated 9 times.

The brake pads are usually applied with nominal contact pressure range of 0.2 to 2 MPa. The load applied on the pin is determined from this pressure as follows:

For pressure (P) = 0.3 MPa

$$\text{Load } F = \frac{\pi}{4} * d^2 * P$$

$$F = \frac{\pi}{4} * 8^2 * 0.3$$

F = 15 N

For pressure (P) = 1 MPa

$$\text{Load } F = \frac{\pi}{4} * d^2 * P$$

$$F = \frac{\pi}{4} * 8^2 * 1$$

F = 50 N

For pressure (P) = 2 MPa

$$\text{Load } F = \frac{\pi}{4} * d^2 * P$$

$$F = \frac{\pi}{4} * 8^2 * 2$$

F = 100 N

The dry sliding tests are usually conducted at ambient temperature and humidity with sliding speeds in the range of 2-20 m/s. The total number of revolutions can be determined from sliding speed by considering wear track diameter of 100 mm.

For sliding speed V=1 m/s

$$\text{Sliding speed } V = \frac{\pi dn}{60000}$$

$$1 = \frac{\pi * 100 * n}{60000}$$

n = 191 rpm

For sliding speed V=2.5 m/s

$$\text{Sliding speed } V = \frac{\pi dn}{60000}$$

$$2.5 = \frac{\pi * 100 * n}{60000}$$

n = 477.7 rpm

For sliding speed V=5 m/s

$$\text{Sliding speed } V = \frac{\pi dn}{60000}$$

$$5 = \frac{\pi * 100 * n}{60000}$$

n = 955.41 rpm

The process factors, their designation and three levels selected are given in Table 1.

Table 1

Sr.No.	Parameter	Code	Unit	Levels		
				Level 1	Level 2	Level 3
1.	Load	A	N	15	50	100
2.	Speed	B	RPM	191	477	955
3.	Temperature	C	^oC	150	200	250

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Performing the Experiment

Form the full factorial design for 3^3 factorials. The total numbers of experiments performed are $27(3^3 = 27)$.

Based on this design the actual parameters are tabulated as shown in Table 2.

Table 2
runs for experiment

Sr. No.	Load	Speed	Temperature
1	100	477	150
2	50	477	150
3	15	477	150
4	100	191	150
5	15	955	150
6	50	955	150
7	100	955	150
8	15	191	150
9	50	191	150
10	100	955	200
11	50	955	200
12	100	477	200
13	15	191	200
14	100	191	200
15	50	477	200
16	50	477	200
17	15	955	200
18	50	191	200
19	50	191	250
20	100	477	250
21	50	477	250
22	15	191	250
23	50	955	250
24	15	955	250
25	100	955	250
26	100	191	250
27	15	477	250

III. CONCLUSION

Based on the exhaustive literature review and study, the following conclusions are drawn.

1. Wear rate can be determined by performing friction & wear test on pin on disc apparatus.
2. The NAO materials can be proper replacement for conventional asbestos brake pads.
3. The most significant parameter can be determined by ANOVA method.
4. The results obtained by experimentation can be compared with conventional brake pad results.
5. Study of worn surfaces of tested samples can be done using SEM

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