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Selection of the Disc Brake Material Using Pin on Disc Apparatus: A Review

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***Abstract* - An automobile brake disc is a device used for slowing or stopping the motion of a wheel while it runs at certain speed. The mostly used brake disc material is cast iron which consumes much fuel due to high specific gravity. The main aim is to develop the material selection and select optimum material for the application of brake disc system for better working. The paper describes the tribological behavior of the conventional materials i.e. Gray cast Iron, Structural steel, Aluminum and High speed steel (HSS). In this paper to check major tribiological parameters for these four materials and try to suggest better new material compared to conventional existing material. After Test on wear machine we find the best suitable material for disc brake applications because of its low wear rate, low frictional force, low coefficient of friction, low cost, better mechanical properties than other.**
***Keywords:* Disc brake, Coefficient of friction, frictional, Force, Tribological aspects, Wear rate etc.**

I. INTRODUCTION

In today's growing automotive market the competition for better performance vehicle is growing enormously. The racing fans involved will surely know the importance of a good brake system not only for safety but also for staying competitive. The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc usually made of cast iron or ceramic composites includes carbon, Kevlar and silica, is connected to the wheel and the axle, to stop the wheel [1- 3]. A friction material in the form of brake pads is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. This friction causes the disc and attached wheel to slow or stop. Generally, the methodologies like regenerative braking and friction braking system are used in a vehicle. A friction brake generates frictional forces as two or more surfaces rub against each other, to reduce movement. Based on the design configurations, vehicle friction brakes can be grouped into drum and disc brakes. If brake disc are in solid body the heat transfer rate is low [4-6]. Time taken for cooling the disc is low. If brake disc are in solid body, the area of contact between disc and pads are more. In disc brake system a ventilated disc is widely used in automobile braking system for improved cooling during braking in which the area of contact between disc and pads remains same.

Disc brake systems generate braking force by clamping brake pads onto a rotor that is mounted to the hub. A schematic view of the brake system is shown in Fig.

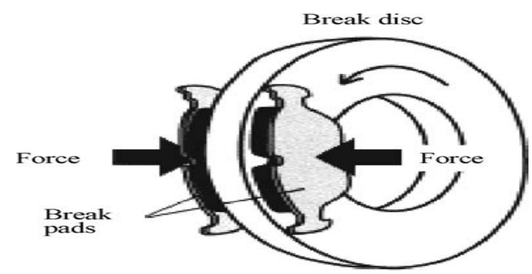

Fig.1 Schematic view of real size brake system (brake disc and brake pad)

II. LITERATURE REVIEW

Ameer Fareed Basha [1] *et al*, studied about the model of a disc brake used in Honda Civic. Coupled field analysis (Structural+Thermal) is done on the disc brake. The materials used are Cast Iron. Analysis is also done by changing the design of disc brake. Actual disc brake has no holes; design is changed by giving holes in the disc brake for more heat dissipation.

V.M.M.Thilak [2*] et al*, made an attempt to investigate the suitable hybrid composite material which is lighter than cast iron and has good Young's modulus, Yield strength and density properties. Aluminum base metal matrix composite and High Strength Glass Fiber composites have a promising friction and wear behavior as a Disk brake rotor. The transient thermo elastic analysis of Disc brakes in repeated brake applications has been performed and the results were compared. The suitable material for the braking operation is S2 glass fiber and all the values obtained from the analysis are less than their allowable values. Hence the brake Disc design is safe based on the strength and rigidity criteria. By identifying the true design features, the extended service life and long term stability is assured.

M.A. Maleque [3] *et al,* the widely used brake rotor material is cast iron which consumes much fuel due to its high specific gravity. The aim of this paper is to develop the material selection method and select the optimum material for the application of brake disc system emphasizing on the substitution of this cast iron by any other lightweight material. Material performance requirements were analyzed and alternative solutions were evaluated among cast iron, aluminium alloy, titanium alloy, ceramics and composites. Mechanical properties including compressive strength, friction coefficient, wear resistance, thermal conductivity and specific gravity as well as cost, were used as the key parameters in the material selection stages. The analysis led to aluminium metal matrix composite as the most appropriate material for brake disc system.

Yildiz and M. Duzgun [4] have studied on a stress analysis of ventilated brake discs using the finite Element method. In this study, three different ventilated brake discs, the cross drilled disc, the cross-slotted disc, and the cross-slotted with a side groove disc, were manufactured, and their braking force performances were investigated experimentally together with a solid disc. Stress analyses were subsequently performed by the finite element method. Analyses results showed that the maximum stress generations were formed on the ventilated discs in comparison to the solid disc. However, these comparisons indicate that the application of varying force distributions along brake pads reduces the stresses on ventilated discs by 8.8% to 19.1%.

Mesut Duzgun [5] has studied Investigation of thermo-structural behaviors of different ventilation applications on brake discs. In this study, the thermal behaviors of ventilated brake discs using three different configurations were investigated at continuous brake conditions in terms of heat generation and thermal stresses with finite element analysis. The results were compared with a solid disc. Heat generation on solid brake discs reduced to a maximum of 24% with ventilation applications. The experimental study indicated finite element temperature analysis results in the range between 1.13% and 10.87%. However, thermal stress formations were higher with ventilated brake discs in comparison to those with solid discs.

III. EXPEERIMENTALSETUP

In this study, the disc brake materials taken under study are Gray cast iron, Structural steel Aluminum and High-speed steel(HSS). These materials are investigated in order to find the possible consequences of wear and friction. The diameter and the length of the pins are 10 mm and 30 mm respectively. For the same surface conditions, the top surfaces of each pin are finished with abrasive paper. The wear rate will be relatively small in most of the machinery and engineering tool. For measuring wear, we are using some apparatus and instruments which give results about the wear rate in the tools and machinery.

The prepared samples were used for tribological test for room temperature on Wear and friction measuring test rig TR-20. The Wear was performed on a pin-on disc apparatus according to ASTM D2538 and ASTM D2396.The test rig was supplied by DUCOM Instrument Bangalore which is shown fig

Fig.2 Wear and friction measuring test rig TR-2

TABLE 1 SPECIFICATIONS OF PIN AND DISC TRIBOMETER (TR-20)

Specifications of pin on disc Tribometer (TR-20)	**MAKe: Ducom Ltd, Bangalore.**
Pin Size	3 to 12 mm diagonal
Disc Size	165 mm dia. X 8 mm thick
Wear Track Diameter (Mean)	10 mm to 160 mm
Sliding Speed Range	0.26 m/sec. to 10 m/sec.
Disc Rotation Speed	100-2000 RPM
Normal Load	200 N Maximum
Friction Force	0-200 N, digital readout, recorder output
Wear Measurement Range	4 mm, digital readout, and recorder output
Power	230 V, 15A, 1 Phase, 50 Hz

TABLE 2 TRIBOLOGY PROPERTIES

Composition	Time in Minutes	Frictional force (N)	Coefficient of friction	Wear in Microns
Gray Cast Iron	0	3.34	0.133	38.37
	5	3.83	0.153	115.53
	10	3.80	0.152	211.83
	15	3.70	0.148	306.79
	20	3.68	0.147	401.62
	25	3.68	0.147	498.45
	30	3.65	0.146	591.20
High speed steel	0	3.79	0.151	3.44
	5	7.01	0.280	84.04
	10	7.05	0.282	113.79
	15	7.06	0.282	378.22
	20	6.55	0.262	579.55
	25	5.08	0.203	585.40
	30	4.23	0.169	586.55
Alu min um	0	8.15	0.163	15.09
	5	7.46	0.150	451.91
	10	7.57	0.151	934.39
	15	7.72	0.154	1403.72
	20	7.74	0.154	1861.04
	25	7.78	0.155	2049.08
	30	6.13	0.122	1577.81
Structural steel	0	17.16	0.343	11.28
	5	16.19	0.323	490.58
	10	24.29	0.485	592.86
	15	25.81	0.516	1376.74
	20	21.15	0.423	1358.46
	25	2.13	0.042	1361.24
	30	2.10	0.042	1361.24

IV. CONCLUSION

It can be concluded from observations and graphs:

1. The value of wear rate found very low in case of Gray Cast Iron as compared to other materials.
2. Gray Cast Iron gives constant low wear rate compared to other when tested under similar working conditions.
3. There is no fluctuation of wear rate in case of Gray Cast Iron and it is almost constant as compared to other materials.
4. Higher frictional force as well as coefficient of friction is observed in case of Structural steel and High Speed Steel.
5. Gray Cast Iron has much good mechanical and thermal properties as compared to others.
6. Gray Cast Iron is best suited for high temperature, high load and medium speed applications. It has durability to withstand heat and pressure.
7. Gray Cast Iron provides protective film on those metal surfaces and combats power and energy-rubbing friction and wear. It helps components last longer, stay cooler and use less fuel to power your vehicle than oil alone.

Hence, Gray cast Iron is best suitable coating material for disc brake applications because of its low wear rate, no fluctuation on wear rate, low cost, better mechanical properties than other materials.

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