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Experimental Analysis of Disc Brake in Aluminium Alloy 6061 Metal Matrix Composites

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ABSTRACT

A disc brake is a device for reducing the speed or stopping the rotation of a wheel. A brake disc (or rotor) usually made of cast iron or ceramic composites are connected to the wheel hub. Friction causes the disc and attached wheel to slow or stop. The thermal and mechanical properties of disc in disc brake are an important factor. There are many types of disc brake. Each one is different of braking performance. So the factors influencing the performance should be found out and a better new or modified disc brake material is created. The defects in existing disc brake are enormous. In order to rectify most of all these defects a new modified disc is modeled using Catia. Finite Element Analysis for the modified composite is done using Ansys software and the experimental works such as stress, hardness, micro structural analysis are carried out.

INTRODUCTION

A braking system is said to be an one of the most important safety components of an automobile. It is mainly used to decelerate vehicles speed from an initial speed to a given speed (Book, W.J., 1990). The controlling of brake is the brake pedal, controlled by driver with foot. Under extreme conditions, such as descending a steep hill with a heavy load, or repeated high-speed decelerations, drum brakes would often fade and loses its performance and lose its effectiveness. Compared with their counterpart, hence disc brakes would operate with less fade under the same conditions. Excessive thermal loading can result in surface cracking, judder and a high wear of the rubbing surfaces. Rise of High temperatures can also lead to overheating of brake fluid, seals and other components. Thus, how to select better geometrical design variables and improve thermal performance and reduce squeal of automotive brake rotor. So new materials is selected to improve the efficiency

1.1 Principle Of Disc Brake:

- Disc brakes use friction to create braking power. A brake is a device by means of which artificial frictional resistance is applied to a moving machine member (Book, W.J., 1990)
- Disc brakes create braking power by forcing flat friction pads against sides of rotating disc (Book, W.J., 1990).
- The energy absorbed by brake is dissipated in the form of heat (Book, W.J., 1990).

1.2 Working Of Disc Brake:

Push rods transfer force through brake booster:

- Master cylinder converts pedal force to hydraulic pressure Hydraulic pressure transmitted to brake lines and hoses to piston(s) to a each brake caliper (Moore, R.E., 1966)
- Pistons operate on friction pads to provide clamping force (Bishop, P.O., 1970).

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- Rotors hence are free to rotate due to wheel bearings and hubs that contain them (Book, W.J., 1990).
- Hub can be part of brake rotor or a separate assembly that the rotor slips over and is bolted to by the lug nut (Book, W.J., 1990).

II. Existing Material For Disc Brake:

Generally, the disc rotor is made of gray cast iron recently some alloys of Aluminium and chromium are used to improve brake efficiency (Ozaki, M., 1998).

Hence cast iron materials made up of hard materials and good wear resistance hence the above materials have high hardness but it as high brittle property to avoid brittleness and some other causes new materials is preferred

III. Preferred Material For Disc Brake:

The Aluminium alloy 6061 is a medium to high strength heat-treatable alloy with strength higher than 6005A. It has a very good corrosion resistance and very good weldability although reduced strength in the weld zone. It has medium fatigue strength. It has a good cold formability in the temper T4, but limited formability in T6 temper (Ozaki, M., 1998).

Not suitable for very complex cross sections. 6061 is a hardening aluminum, containing magnesium and silicon as its having major alloying elements. Originally called "Alloy 61S" it was developed in 1935. It has good mechanical properties and exhibits good weld ability. Hence it is one of the most common alloys of aluminum for general purpose.

It is commonly available in pre-tempered grades such as 6061-O (annealed) and tempered grades such as 6061-T6 (solutionized and artificially aged) and 6061-T651 (solutionized, stress-relieved stretched and artificially aged) (Ozaki, M., 1998).

III.I Composition of Proposed Material:

Table 1:

MATERIAL	PERCENTAGE
Al 6061	88%
Silicon Carbide (SiC)	8%
Magnesium	2%
Graphite	2%

III.II Physical Properties:

Table 2:

PROPERTY	VALUE
Density	2.70 g/cm³
Melting Point	650 °C
Thermal Expansion	23.4 x10-6 /K
Modulus of Elasticity	70 GPa
Thermal Conductivity	166 W/m.K
Electrical Resistivity	0.040 x10-6 Ω .m

IV Tests Conducted:

- Pin-On-Disc
- Tensile Strength
- Brinell Hardness

V -Analysis Results:

V.1 Results Of Cast Iron:

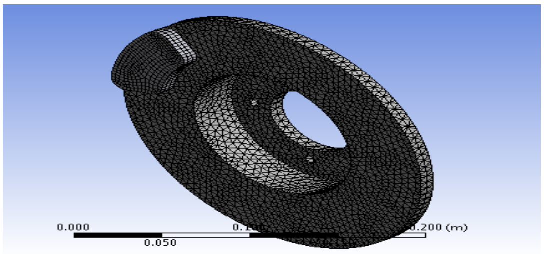

Fig. 1: MESH.

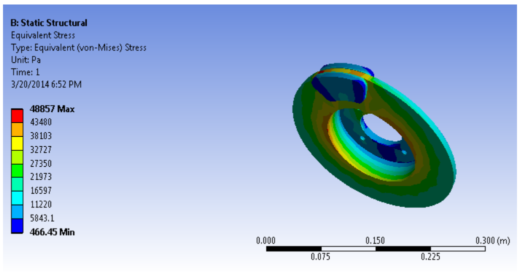

Fig. 2: Von Mises Stress.

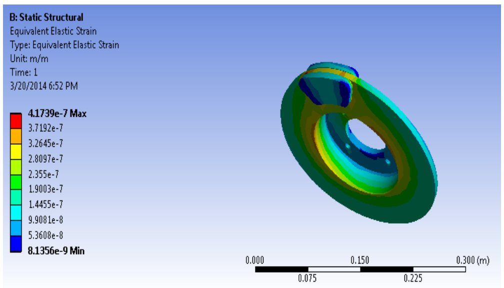

Fig. 3: STRAIN.

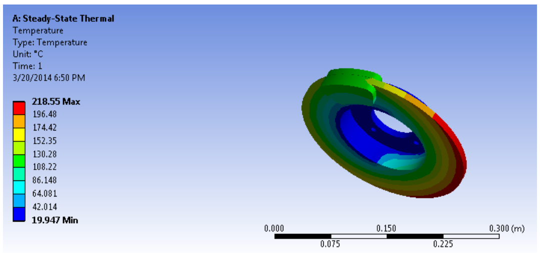

Fig. 4: Temperture.

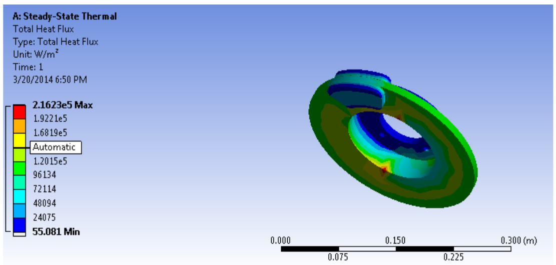

Fig. 5: Heat Flux.

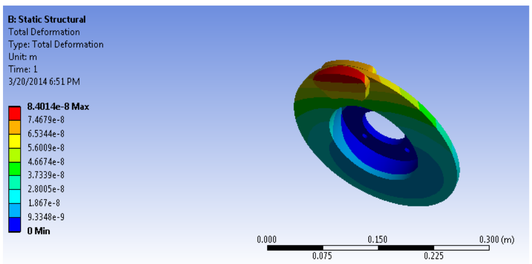

Fig. 6: Total Deformation.

V.II Aluminum Composite Material:

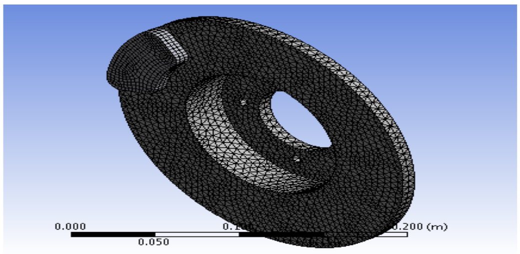

Fig. 7: Mesh.

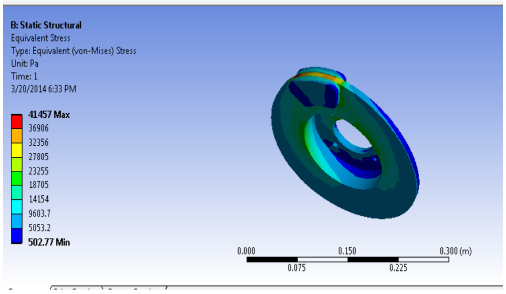

Fig. 8: Von Mises Stress.

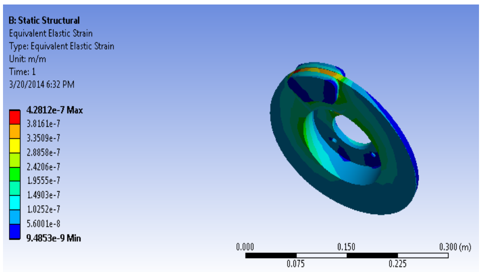

Fig. 9: Strain.

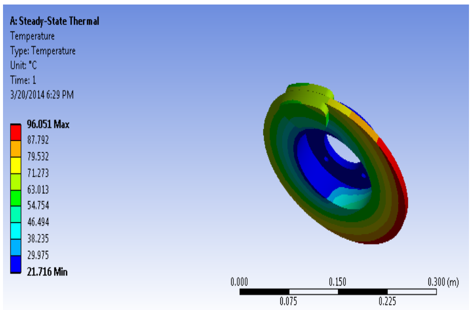

Fig. 10: Temperature**.**

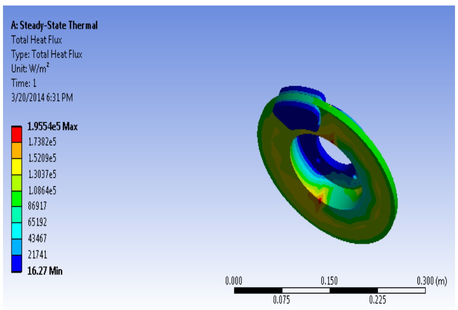

Fig. 11: Heat Fluxe**.**

Australian Journal of Basic and Applied Sciences, 10(1) January 2016, Pages: 152-158

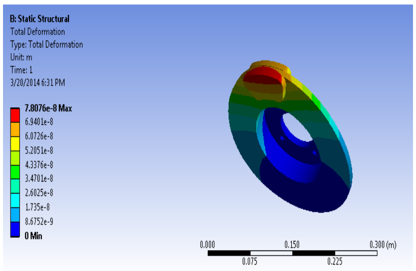

Fig. 12: Total Deformation.

VI Pin On Disc Wear Test:

VI.I Cast Iron:

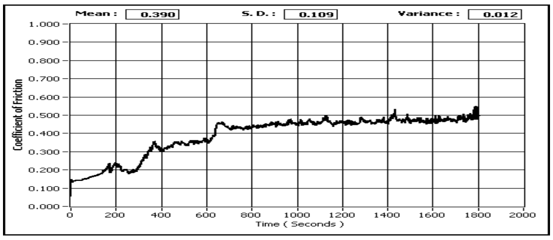

Fig. 13: Coefficient of friction.

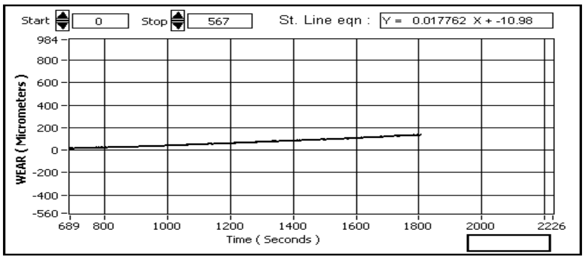

Fig. 14: Displacement.

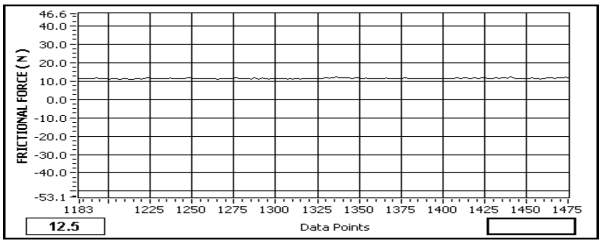

Fig. 15: Friction Force.

VI.II Aluminum Composite Material:

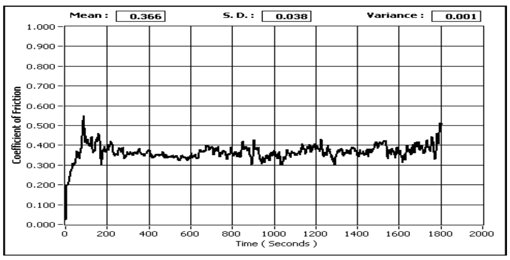

Fig. 16: Coefficient of friction.

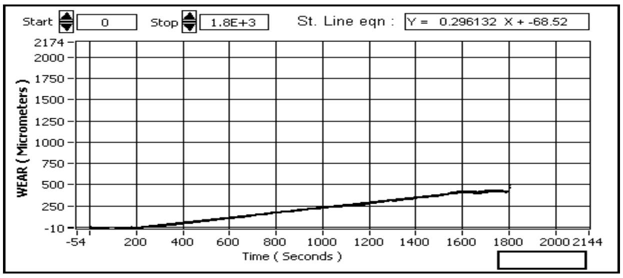

Fig. 17: Displacement.

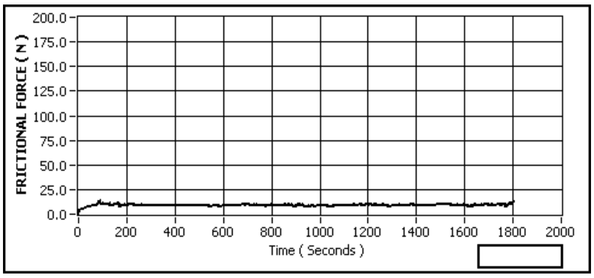

Fig. 18: Friction Force.

VII Hardness and Mcrostructure:

Fig. 19:

Microstructure:

The microstructure reveals Al-Fe-Si & Mg-Si particles in a martix of a aluminum. Solid solution.eutectic particles are in a inter dinetritic structural are observed.

Hardness test:

48.0, 43.6, 46.8 HV 1 Kg load.

VIII Comparison Results Between:
Different Materials:

Table 3:

Property	Cast Iron	Aluminium Composite
Density	7100 kg/m3	2693.6 kg/m3
Young’s Modulus	1.25*10^5	9.76*10^5
Poisson’s Ratio	0.25	0.312
Bulk Modulus	41*GPa*	86*GPa*
Shear Modulus	41	37.2
Thermal Conductivity	54.5Wm.C	150.87Wm.C

Conclusion:

Thus defects in existing disc brake are enormous. In order to rectify all these defects a new modified rotor is modeled using Catia. Finite Element Analysis for the modified composite is done using Ansys software and the experimental works such as stress, hardness, micro structural analysis are carried out

The experimental results thereby conclude that the aluminum composite material is a better replacement for conventional cast iron discs and its implementation in vehicles can improve the overall breaking efficiency.

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