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CATIA V5 ANSYS Based Performance Enhancement on Disc Brake

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Abstract: ***In the modern automobile vehicles the system of braking is the main primary essential parts. It takes up the wheel kinetic energy then dissipates it as heat energy and decelerate or else vehicle stop. While apply the disc brake high stress is generated, therefore problem of frictional wear occur. In order to enhance the functional performance, take thermal analysis for selecting minimum heat flexes material. In this research work, software of Catia v5 as well as ANSYS is used for creating modal and analyzing. The Suggest result materials are fabricated using stir casting method and conducting wear test.***

Keywords: ANSYS, Braking System, CATIA V5, Thermal Analysis

I. INTRODUCTION

Now a day's automobile vehicles frequently employ the permutation with disc brakes as well as drum brakes. In order to understand the behavior of braking system has to satisfy the functions that maintain a constant speed when travelling, vehicle stop and hold the cars immobile. Craciun et al (2015) stated that the torque of the brake is subjective through random factor number for example the climate condition as well as surface type of operating cars [1]. Eltoukhy et al (2008) found that when thermal judder happen because the outcome of uneven contact among pad as well as rotor of the disk brake [2]. Hartsock et al (2000) stated that the unsteadiness of thermo elastic takes place while the perturbation of the pressure into the arrangement could make the reason for generating high energy at the rotor's specific point [3].

Laguna et al (2015) studied the system of brake mechanism related to wear through various investigators. The wear behaviour is relatively random of contact differences so as to exist with precise as well as complex of the systems [4]. Craciun et al (2015) investigated for enhancing the functional aspects of the disc brake and it's improve brake discs performance concerning its performance based on the friction among the pads of the brake [5]. Thilak et al (2007) investigated the solid rotor temperature distribution using the theorem of Duhamel. [6]. Limpert et al (1992) accomplished the equation of temperature assumption with the flux of heat at constant and speed of downhill brake [7]. Newcomb et al (1967) found that the rotor made by steel material has minimum temperature along with other materials at the same

time the rotor made by duralumin has maximum temperature [8].

Choi et al (2004) carry out the analysis of disc brake thermo elastic transient application by FEA technique with the creation of friction [9]. Faruk et al (2006) estimated car brake disk rotor under servicing condition including various materials like E glass as well as S_2 class [10]. You et al (2000) developed numerical technique to analyze the rotational disc deformation as well as stress of elastically plastic having the cross section with arbitrary density of variable strain hardening metal [11]. Bektas et al (2005) deliberated the brake disk made by metal matrix composite of aluminium elastically plastic analysis of stress based on internal pressure [12].

In the present work, software of Catia v5 as well as ANSYS is used for analyzing. The Suggest result materials are fabricated using stir casting method and conducting wear test.

II. PRINCIPLES OF SYSTEM OF BRAKING

The material used to make disk of the brake is cast iron which is joined with the hub of the wheel along with the fixed housing named as caliper. The caliper is further fitted with the casing of the axle named as stub axle with piston. The piston as well as disc are positioning with the frictional pad through retaining pins, spring plates etc.

The schematic of the hydraulic disc brake is shown in Figure 1.

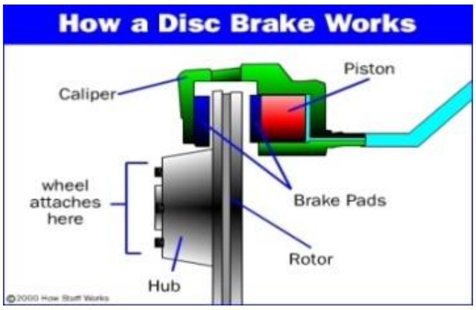

Figure 1: Schematic of hydraulic disc brake

When the brake is applied, the frictional pad gets mechanical movement through the hydraulically actuated piston and get in touch with brake.

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Due to reason of resistance due to the friction among the disc of the brake as well as surface of the pad, the wheels kinetic energy has changed as a heat. So, the car has stopped after particular space. Brake pad is liberated the heat through pad as well as brake disc causes of uneven heat distribution towards the components could induce severe brake disc deformation through thermo elastic.

A. Disc Brake Rotor

In the assembly of disc brake the rotor is the part which biggest as well as largest. They provide friction surfaces for the linings for rubbing and form the couple of friction for vehicles gets stop. In the solid rotor the frictional surface is opposite to the metal solid piece. The schematic of disc brake rotor is shown in Figure 2.

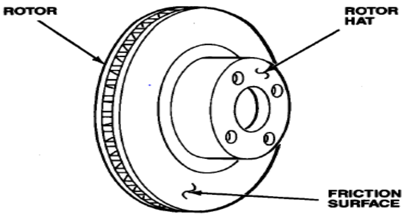

Figure 2: Schematic of disc brake rotor

The Schematic of solid and vented disc brake is shown in Figure 3.

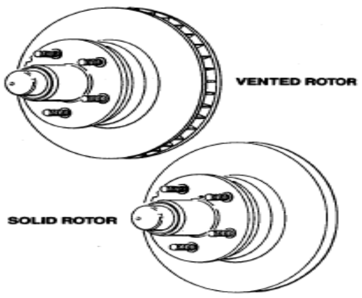

Figure 3: Schematic of solid and vented disc brake

B. Functions of Disc Brake

On primary role of the rotor in the brake is the transmission of power from caliper to rim. The other functions of the disc brake are the distribute the power needed for brake; hold the stress; space provision for steering, assembly of the knuckle joint; system of suspension. It has capable to withstand the retardation stress as well as strain. Minimum aspects of level of the functional sound, cost for life cycle rate of pollution, consumption of energy and materials are the functional requirement and giving reliability as well as safety.

C. Damages of Disc Brake Rotor due to Friction

Cracking

The form of cracking could be appeared on the rotor parts normally the frictional surface edge. Figure 4 displayed the schematic of crack formation.

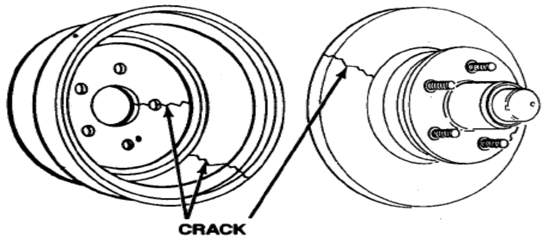

Figure 4: Schematic of crack formation of disc brake

III. EXPERIMENT TEST

Metal matrix composite manufacturing can be broken into three types: solid, liquid, and vapor. In this project Liquid state method is selected for manufacturing the Aluminium composites.

A. Stir casting

Solidification is the process of string the molten metal through reinforce discontinuously. In stir Casting the materials are fabricating in the state of liquid and the phase is dispersed and combined by means of molten matrix metal through mechanical stir. Then it is transferred into a preheated and percolated transfer ladle. The material is stirred again and then poured into the stable mould with preheating. Then it has cooled; shaped by cutting in addition to cleaned its surfaces.

The Figure 6 shows the bottom pouring stir casting machine.

Figure 6: Bottom Pouring Stir Casting Machine

Aluminium alloy (6061) first superheated to its melting point in graphite crucible. Powder MgO and Gr preheated in the different temperatures like 250 and 350ºC and then is wrapped into aluminum foils.

Finally, specimens are fabricated in good conditions are prepared for subsequent wear analysis. The preparation of sample is tabulated in Table 1.

Table 1 Sample preparation

Specimen	AL 6061	MgO	Gr	Total
	G	g		
Sample 1	1000	0	0	1000
Sample 2	985	7.5	7.5	1000

The AL6061 base alloy specimen is shown in Figure 7.

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Figure 7: AL6061 base alloy sample

The reinforcement of the sample is shown in Figure and the Wear sample –ASTM G99 are shown in Figure 8 and 9 respectively.

Figure 8: Reinforcement of sample

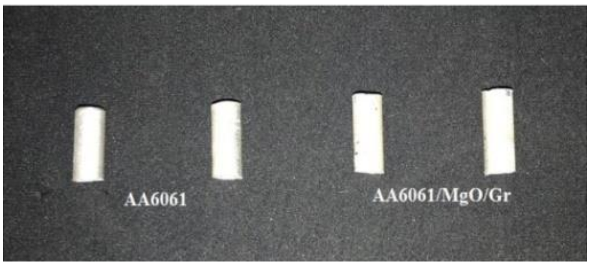


Figure 9: Wear sample –ASTM G99

B. Pin on Disc Wear Test

The technique for wear testing through pin on disc is useful for finding out the characterization of frictional coefficient; force due to friction and the wear rate among the two metals. On the test of s tribological, a stationary disk articulates against a rotating pin while under a constant applied load.

The Pin- on disc wear testing arrangement and its machine are shown in Figure 10 (a) and (b). Abrasive and erosive wear processes, where particle size, incidence angle; wear due to erosive; velocity of the particles and distribution parameters are very essential for modelling with full scale.

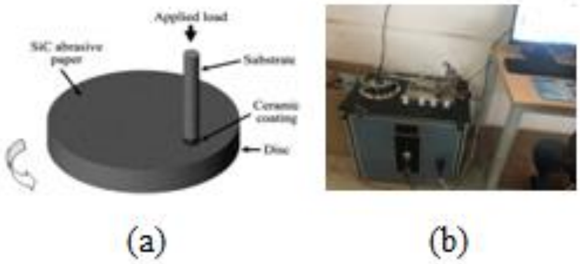


Figure 10: (a) Pin- on disc wears testing arrangement (b) Machine

Dry sliding wear behavior of the Al-Sic + various leaf ashes composite has made at room temperature.

IV. MODELLING

The name of the current available various modelling software are Inventor; Pro E; Catia Solid edge; Ideas; Mechanical desktop and so on. In this research work the design is developed by using V5 grade Catia Software.

By using this software the design complex activities could be made very easily through its capability of parts as well as modeling integration with 3D parametrical. The developing parts having shape of angular, applied surface related to 3D for developing hybrid with angular as well as shape with curve. The dimensions and modelling of the disc brake are tabulated in Table 2 and Figure 11.

Table 2: Geometrical dimensions of Cayman S vehicle break disc

Item	Values
Disc Diameter	298 mm
Disc Thickness	24 mm
Overall Height of automobile	68 mm
Centre Diameter	98 mm
Size of pad	114*78*16
Weight of Automobile	1330 kg
Top Speed of Automobile	160 mph
Tire Size	235/45ZR18
Effective Radius of Rotor, R_r	110 mm
Mass of the disc	5 kg
Specific heat, C_p	450 $Jkg^{-1}k^{-1}$
Deceleration	12.9 ms^{-2}

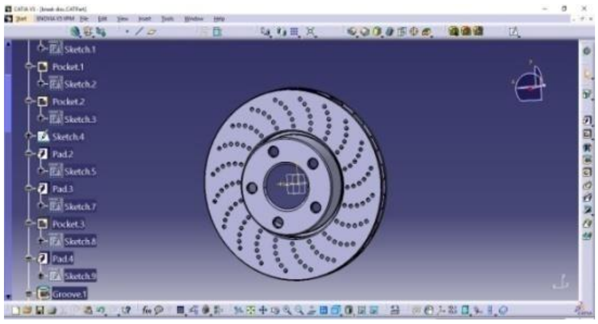


Figure 11: Modeling of solid disc brake modelling

V. ANALYSIS WITH FINITE ELEMENTS

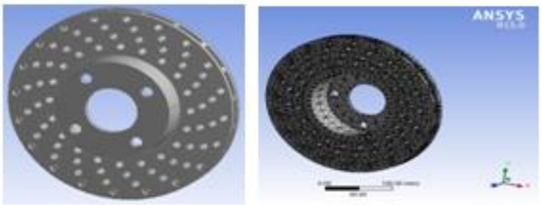
This technique has numerical method to get average solutions for the different engineering problems. The properties of the materials are tabulated in Table 3.

Table 3: Material properties

Properties	*AL6061/SiC/Gr*	AL6061/MgO/Gr	Cast iron
Density (kg/m^3)	2850	2760	7100
Young's modulus (Gpa)	114	99	126
Thermal Conductivity (W/m.k)	149	182	55
Specific heat (J/KgK)	830	850	580
Poisson ratio	0.35	0.33	0.27

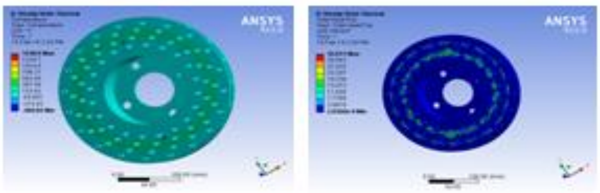
Importing of Catia Model in to ANSYS

The 3D modeling and meshing of the disc brake in Electric vehicle is shown in Figure 12 (a) and (b). The effect of temperature and total heat fluxes of the materials of AL6061/SiC/Gr are shown in Figure 13 (a) and (b) respectively.



(a) (b)

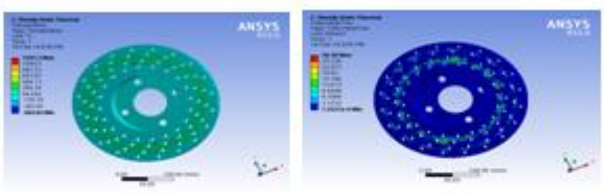
Figure 12: (a) 3D Modeling (b) Meshing of rotor disc brake in Electric vehicle



(a) (b)

Figure 13: Effect of (a) temperature (b) total heat fluxes of the material AL6061/SiC/Gr

The phases involving this process are Pre-processor phase, solution phase and Post-processor phase. The effect of temperature and total heat fluxes of the materials of AL6061/SiC/Gr are shown in Figure 13 (a) and (b) respectively. The effect of temperature and total heat fluxes of the materials of AL6061/MgO/Gr are shown in Figure 14 (a) and (b) respectively. The effect of temperature and total heat fluxes of the materials of Cast iron are shown in Figure 15 (a) and (b) respectively.

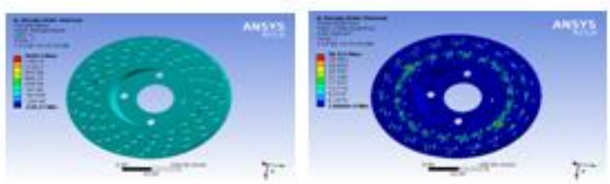


(a) (b)

Figure 14: Effect of (a) temperature (b) total heat fluxes of the material AL6061/MgO/Gr

Table 4: AL6061/MgO/Gr shows low temperature compare to other materials

Material	Max/Min	Temperature (^{0}C)	Heat Flex (w/mm^2)
AL6061/SiC/Gr	Min	-489.04	2.935e-
	Max	1438.9	34.811
AL6061/MgO/Gr	Min	-504.84	7.252 e-
	Max	1293.3	28.38
Cast iron	Min	-528.27	7.6069e-
	Max	1620.1	38.321



(a) (b)

Figure 15: Effect of (a) temperature (b) total heat fluxes of the material Cast iron

VI. RESULTS AND DISCUSSION

The break disc has been modeled using 3D modeling software CATIA V5. Catia Model of Break disc is saved as IGES (neutral) file and transferred to ANSYS work bench 15.0 software. Steady state thermal analysis is performed of alloy wheel by applying the heat flex, conduction, radiation on the disc surface. Steady state thermal analysis is performed on three different materials such as AL6061/SiC/Gr, AL6061/MgO/Gr and cast iron on same boundary condition. According to result table AL6061/MgO/Gr showing least heat flex and temperature. So we can conclude that AL6061/MgO/Gr is best material for Break disc compare to other two materials. The results values are tabulated n Table 5 and the comparison chart is shown in Figure 16.

Table 5: Test results values

Specimen	Track Radius (mm)	Speed (RPM)	Load (Kg)	Time (Min)	Wear (Micron)		
AA6061	50	500	23	2	69	67	68

AA6061/ MgO/ Gr	50	500	25	2	55	57	56

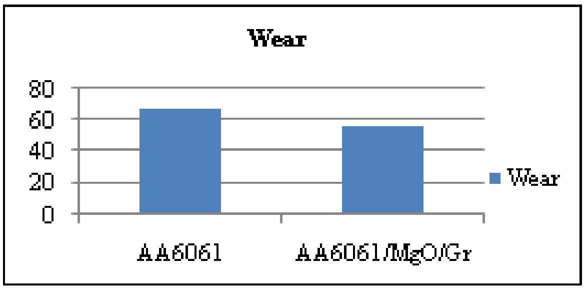


Figure 16: The results comparison chart

In wear test method two different sets (as-casted in 1 and 1.5% composition) of pins are constructed through composite. The dimensions of the pin are 8 mm dia along with this length is 30 mm. Also counter part of the disc has outside dia 70 mm and thickness 10 mm fabricate through high carbon as well as chromium steel. Every test pin is loaded including dead weight against disc. At the room temperature all the tests are carried out by the way of permanent wear parameters of 9.8 N load 1 meter/second speed intended 20 minutes. The pin weight is determined by using digital weight balance machine among the precision with 1 mg during test before and after.

At constant sliding speed with respect of track dia and the disc angular speed respectively 50 mm and 400 rpm. Every test for wear is performed with the sliding distance approximate 1.25 Km. Frictional torque is given on pin while drum rotating. The changeable arm fitted with the pin next frame and the load cell is being fitted with this equipment. The rate of wear is determined through the measurement of weight loss. While experiment, frictional torque is noted along with frictional co-efficient following with regular rules.

VII. CONCLUSION

AL6061 and AL6061/MgO/Gr samples successfully fabricated by stir casting method. Pin on Disc apparatus used for wear test. The weight loss and wear rate decreases with increasing graphite content, its give superior wear properties compare to AL6061. Mean while AL6061/MgO/Gr also least dense material then AL6061. From our design and fabrication results, we have concluded that AL6061/MgO/Gr has suitable material for break disc application

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