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Modeling and Thermal Analysis of Disc Brake

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ABSTRACT
The disc brake is a device used for slowing or stopping the rotation of the vehicle. Number of times using the brake for vehicle leads to heat generation during braking event, such that disc brake undergoes breakage due to high Temperature. Disc brake model is done by CATIA and analysis is done by using ANSYS workbench. The main purpose of this project is to study the Thermal analysis of the Materials for the Aluminum, Grey Cast Iron, HSS M42, and HSS M2. A comparison between the four materials for the Thermal values and material properties obtained from the Thermal analysis low thermal gradient material is preferred. Hence best suitable design, low thermal gradient material Grey cast iron is preferred for the Disc Brakes for better performance.

***Keywords* -** ANSYS, CATIA, Disc Brake, Thermal Analysis

I. INTRODUCTION

In today's growing automotive market the competition for better performance vehicle is growing enormously. The disc brake is a device used for slowing or stopping the rotation of the wheel. A brake is usually made of cast iron or ceramic composites include carbon, aluminum, Kevlar and silica which is connected to the wheel and axle, to stop the vehicle. A friction material produced in the form of brake pads is forced mechanically, hydraulically, pneumatically and electromagnetically against the both side of the disc. This friction causes the disc and attached wheel to slow or to stop the vehicle. The methods used in the vehicle are regenerative braking system and friction braking system. A friction brake generates the frictional force in two or more surfaces rub against to each other, to reduce the movement. Based on the design configurations vehicle friction brakes are grouped into disc brakes and drum brakes. Our project is about disc brakes modeling and analysis.

Fig 1 Disc brake Assembly

1.1 TYPES OF BRAKES

Brakes are described into three types according to usage they are

1.1.1Frictional Brakes
1.1.2 Pumping Brakes
1.1.3 Electro-Magnetic Brakes

1.1.1 Frictional Brakes

Frictional brakes are most common and can be divided broadly into "shoe" or the "pad" brakes, using the explicit wear surface, and the hydrodynamic brakes, such as the parachutes, which use the friction as a working fluid so that it do not explicitly wear. Typically the term "friction brake" is used to mean pad/shoe brakes and excludes hydrodynamic brakes, even though hydrodynamic brakes use friction. Friction (pad/shoe) brakes are often rotating devices with a stationary pad and a rotating wear surface. Common configurations include shoes that contract to rub on the outside of a rotating drum, such as a band brake; a rotating drum with shoes that expand to rub the inside of a drum, commonly called as a "drum brake", although the other drum with the configurations are possible; and pads that pinch a rotating disc, commonly called as the "disc brake", other brake configurations which are used, such that less often. For example, we take PCC trolley brakes which include a flat shoe which is clamped to the rail with an electromagnet; the Murphy brake pinches the rotating drum, so the Ausco Lambert disc brake which uses the hollow disc (two parallel discs with a structural bridge) with shoes that sit between the disc surfaces and expand laterally.

1.1.2 Pumping Brakes

Pumping brakes are often used where a pump is already part of machinery. For example, we take an internal-combustion piston motor can have the fuel supply by stopping, and the internal pumping losses of the engine create some braking. Some engines use a valve override is called a Jake brake to greatly increase pumping losses. Pumping brakes can dump the energy into heat, or it may be regenerative brakes that recharge the pressure reservoir is called as hydraulic accumulator.

1.1.3 Electromagnetic Brakes

Electromagnetic brakes are likewise often used where an electric motor is already part of machinery. For example, we take many hybrid gasoline vehicles or electric vehicles use the electric motor as a generator to charge electric batteries and also as a regenerative brake system. Some diesel or electric railroad locomotives use the electric motors to generate electricity which is then sent to a resistor bank and dump into heat. Some vehicles, we consider transit buses, does not already have the electric motor but use a secondary "retarder" brake that is effectively a generator with an internal short-circuit.

II. MODELING OF DISC BRAKE IN CATIA

CATIA software is the standard in the 3D product design, featuring industry-leading productivity tools that promote one of the best practices in design while ensuring compliance regarding industry and company standards. The designing of CATIA solution allow you to design you faster than any other software. The figure shows the solid model of the disc brake by using CATIA. By taking the pulsar disc brake dimension we have to draw the disc brake model in CATIA.

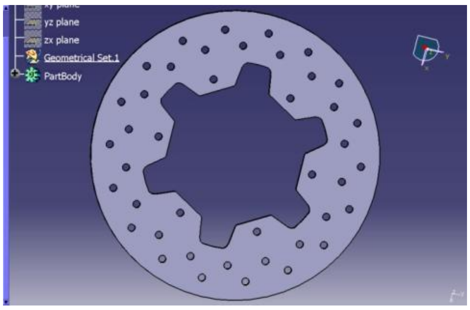


Fig.2 Disc Brake Model in CATIA

III ANALYSIS BY USING ANSYS

Dr. John Swanson founded ANSYS. Inc in 1970 with a vision to commercialize the concept of computer simulated engineering, establishing himself as one of the pioneers of Finite Element Analysis (FEM). The software implements the equations that govern the behavior of these elements and solve the problems, by creating comprehensive explanation of how the acts as whole. The results can be obtained in the form of tabular column or graphical forms.

Steps followed in ANSYS:

These are the common steps involved in the ANSYS process

1) Preliminary Decisions
    a. Analysis type
    b. Model
    c. Element type
2) Pre processing
    a. Material
    b. Import the model
    c. Mesh the model
3) Solution
    a. Apply loads
    b. Solve
4) Post processing
    a. Review results
    b. Check the solution

Elements considered for thermal analysis: For analysis solid 20 node 90 is preferred for the structural analysis. 20 node 90 is preferred for the higher order version of the three dimensional eight node thermal element. The element is defined by the 20 nodes having three degrees of freedom per node.

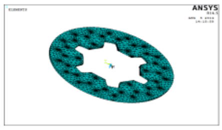


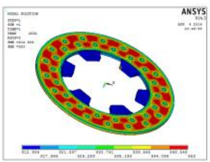
Fig 3.1Imported Model Fig.3.2Meshed Model

The above shown Fig 3.1 is the imported model in the ANSYS from CATIA. Fig3.2 is the meshed model in which solid 20 node 90 is used.

3.1THERMAL ANALYSIS OF DISC BRAKES

The thermal analysis is performed by using ANSYS for Aluminum, Grey Cast Iron, HSS M2 and HSS M42.

3.1.1 Aluminum Thermal Analysis



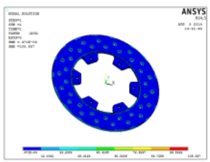


Fig3.3 NodalTemperature **Fig3.4**Thermal Gradient

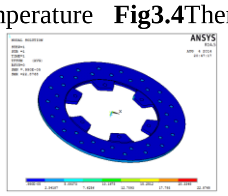
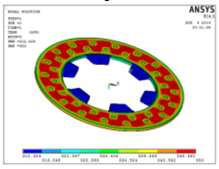


Fig3.5 Thermal Flux

The Aluminium Nodal Temperature minimum value is 312.934k and the maximum value is 353k, thermal Gradient minimum value is 0.42765 and the maximum value is 108.125, thermal flux minimum value is 0.9903 and the maximum value is 22.8768.

3.1.2 Grey Cast Iron Thermal Analysis



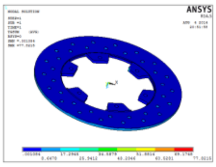


Fig3.6 NodalTemperature **Fig 3.7** ThermalGradient

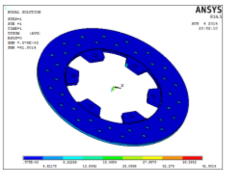
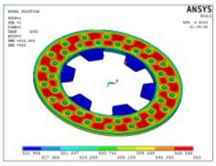


Fig 3.8 Thermal Flux

The Grey Cast Iron Nodal temperature minimum value is 312.329k and the maximum value is 353k,thermal gradient minimum value is 0.007125 and the maximum value is 77.125, thermal flux minimum value is 0.5786 and the maximum value is 41.5014.

3.1.3 HSS M42 Thermal Analysis



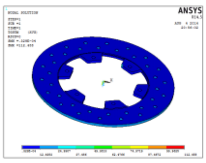


Fig 3.9 NodalTemperature **Fig3.10**ThermalGradient

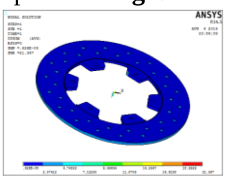


Fig 3.11 Thermal Flux

The HSS M42 Nodal Temperature minimum value is 312.934k and the maximum value is 353k, Thermal Gradient minimum value is 0.1293 and the maximum value is 110.4567, Thermal Flux minimum value is 0.7365 and the maximum value is 24.9675.

3.1.4 HSS M2 Thermal Analysis

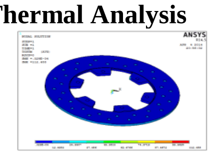


Fig3.12 NodalTemperature

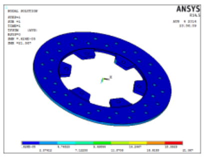


Fig3.13 ThermalGradient

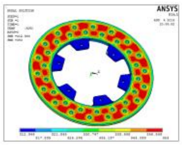


Fig3.14 Thermal Flux

The HSS M2 Nodal Temperature minimum value is 312.944k and the maximum value is 353k, Thermal Gradient minimum value is 0.32945 and the maximum value is 112.4586, Thermal Flux minimum value is 0.0264 and the maximum value is 21.3475.

IV RESULTS AND DISCUSSIONS

Table 4.1 Analysis of Nodal Temperature

Material	Minimum Temperature	Maximum Temperature
Aluminum	312.934	353
Grey Cast Iron	312.329	353
HSS M2	312.944	353
HSS M42	312.934	353

By considering the Table 4.1 Nodal Temperature Analysis for Disc Brake we can say that Aluminum, Grey cast Iron, HSS M2 and HSS M42 has 353k nodal temperature from the Analysis in ANSYS.

Table 4.2 Analysis of Thermal Gradient

Material	Minimum Load	Maximum Load
Aluminum	0.42765	108.125
Grey Cast Iron	0.007123	77.125
HSS M2	0.32945	112.4586
HSS M42	0.12943	110.4567

By considering the Table 4.2 Thermal Gradient Analysis for disc brake we can say that Grey Cast Iron has low Thermal Gradient Compared to the remaining materials Aluminum, HSS M2 and HSS M42 from the analysis in ANSYS.

Table 4.3 Analysis of Thermal Flux

Material	Minimum Load	Maximum Load
Aluminum	0.9903	22.8768
Grey Cast Iron	0.5786	41.5014
HSS M2	0.0264	21.3475
HSS M42	0.7365	24.9675

By considering the Table 3 Thermal Flux Analysis for Disc Brake we can say that HSS M2 has low Thermal Flux compared to remaining materials Aluminum, Grey cast Iron and HSS M42 from the Analysis in ANSYS.

V CONCLUSION

The Disc Brake designed in CATIA is imported to the 'iges' formatte which is exported to the ANSYS. Then the Thermal Analysis is performed for the materials Aluminum, Grey Cast Iron, HSS M2 and HSS M42 and the results are obtained in the form of tables. By comparing the four materials Grey Cast Iron has low thermal gradient and it is best suitable for Disc Brake for better performance. Hence the Disc Brake design is safe based on the strength and rigidity criteria.

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