

Analysis of Custom Parts of Hydraulic Braking System used in Electric All-Terrain Vehicle

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Abstract—Brakes is defined as the force applied on the rotating wheel axially on the brake disc to stop the vehicle. The braking system is the most important part in accordance of confirming the driver's safety. So, the components designed are safe or not is to be confirmed and if not then re-design by changing the parameters considered. To confirm the design of custom parts of braking system like brake disc and brake pedal is safe or not, analysis of this parts is performed before confirming the design. This paper briefly explains about "how analysis of brake pedal and brake disc are performed". The type of brake disc used is slotted brake disc and the pedal is a cantilever brake pedal. The software used to analyze these two components is Ansys and process used are steady state thermal (for brake disc) and static structural (for brake disc as well as for brake pedal). This paper deals with all the information, processes used and the calculation needed for designing and analyzing the brake disc and the brake pedal. It validates the design proposed and obtained after proper calculation of the designs.

Keywords—Analysis, Brake disc, Braking system, Brake pedal, Custom parts.

I. INTRODUCTION

The braking system in the vehicle plays the important role in accordance with the driver's safety. The braking system used here is hydraulic braking system and type used is disc brake. As the type of brake used is decided considering that the disc used should dissipate heat as it leads to generation of heat after applying so type of brake used is disc type, it is important to understand that the brake disc used is safe and effective and provides effective heat dissipation while braking. This paper also gives us brief idea about analysis of the other parts of braking system i.e. brake pedal that are customized.

II. OBJECTIVES

The main objective to do analysis of the custom parts of the brake system is to understand that the product designed is safe virtually as well as the theoretical calculation performed are correct. The analysis also helps us to understand the failure and stresses that may occur in the design. Accordingly, changes are to be made in the design and part is made safe to manufactures. Design of the disc for a disc brake system using load analysis, stress analysis and thermal analysis system approach [4]. This will not only ensure that the brake system designed is safe but it will also ensure the driver and passenger system

III. MATERIAL AND METHOD

The following details are the parts that are to be analyzed and their specification are specified accordingly. The method used for analysis is based on the engineering subject named Computer Aided Design and Finite Element Analysis. This subject gives brief information about the analysis and designing of the component is safe and is ready for machining.

3.1 MATERIAL AND REASONING

The parts that are customized in braking system are

1. Brake Disc
2. Brake Pedal

3.1.1 BRAKE DISC:

The brake disc is also known as brake rotor. This helps for effective heat dissipation of heat that is generated due to friction between the brake disc and the brake pad of the caliper. The brake disc type is further classified into three different types:

1. Slotted disc, 2. Vented disc, 3. Drilled disc

The difference between the above-mentioned disc types is mentioned below:

**I. TABLE 1
 COMPARISON BETWEEN DIFFERENT TYPES**

Sr. No.	Slotted	Vented	Drilled
01.	Have different slots of different dimensions	Have openings or vents to pass the air	Have drill hole of different size
02.	More heat dissipation than drilled disc	Heat dissipation is more than both other types	Heat dissipation is less than both
03.	Cost for manufacturing of this type of disc is not more than vented	Cost for manufacturing of this type of disc is very high	Cost for manufacturing of this type of disc is less than vented as well as slotted
04.	Less effective than vented for dissipation of heat and is light in weight	This type of disc is the most effective but weight is more than other two	This disc is less effective and is more in weight than slotted

Material used:

The material used for brake disc is SS-420. This material is selected because it is ductile, hard, strong, have magnetic property, malleable etc. the yield strength of this material is 360 MPa. The suitable hybrid composite material which is lighter than cast iron and has good Young's modulus, Yield strength and density properties.

Properties of Stainless Steel-420

Density: 7800 kg/m³

Elastic modulus: 200GPa

Thermal conductivity: 24.9 W/m.K

3.1.2 BRAKE PEDAL:

The brake pedal system is the cantilever linkage which is assembled on the master cylinder and designed according to the master cylinder as well as the driver's comfort. The analysis of brake pedal tells us about the fatigue failure as well as the stress applied is safe or not. The force applied on the brake pedal is 350N and the pressure that oppose the piston attached to pedal. The brake pedal helps to actuation of the brake pedal. The material used is en-8 and the reason to use this material is it is strong, hard and have high fatigue strength.

3.2 METHODOLOGY

The software used for analysis of braking system is Ansys workbench. The analysis performed on brake disc is structural and thermal analysis and on brake pedal is structural and fatigue testing is done to understand the factor of safety. The analyses of this components will help to understand the design and calculation used are safe to perform the machining of the part with the selected material.

The material used is decided after testing the part design in Ansys under different conditions for different material. The material tested were grade of stainless steel-304, 316, 420. The brake pedal material decided is the strongest material therefore no other material was used for it while analysis.

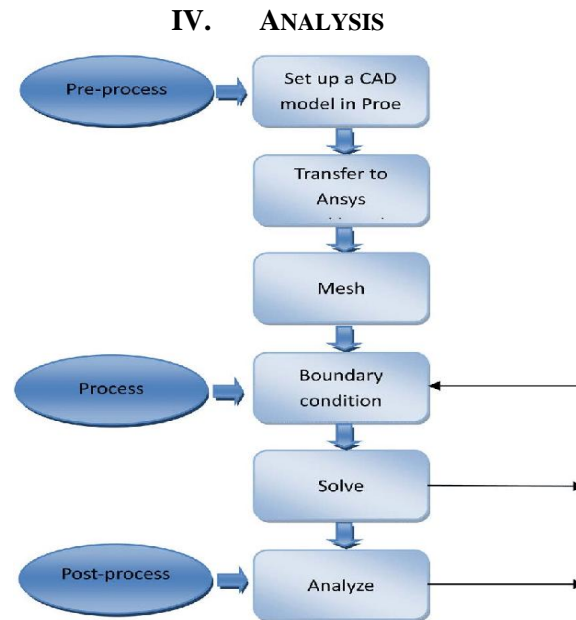


FIGURE1: Flow chart for analysis

The above figure [fig.1] is the flow chart of the basic process that is followed for performing the analysis of the customized part of the electric all-terrain vehicle. The first step of the analysis is called as preprocess which includes three sub parts. The first step of the pre process is to set up a cad model in proe and then transfer the cad model to the Ansys. After completion of transfer of the cad model generate the mesh. The meshing helps to divide the model into small number of elements. The importance of this elements is, more the number of elements more accurate are the results. After completing the pre process the second step is to start with the process which includes boundary condition and solve the analysis to get the results accordingly. The third step is to observe the process done on the part is safe and the problems that can be caused and the changes are made for safe design so that the virtual cad model can be manufactured.

4.1 Analysis of brake disc

Brake Disc:

4.1.1 Design parameters of disc brake:

Brake rotor material = SS-420

Brake rotor dimension = 240mm

Yield stress of grey cast iron = 360 MPa

Pad brake area = $2000 * 10^{-6} \text{ m}^2$
 Maximum pressure = 8 bar
 Maximum temperature = 100°C

The brake disc analysis is carried in two ways:

4.1.2 Steady State Thermal analysis: The steady state thermal analysis is done because clamping force applied by brake caliper on the brake disc gives rise to temperature of brake disc. The brake fluid is passed through brake lines which actuate the piston of the caliper and apply pressure on the pad. The reason to use this method for analysis of brake disc is to understand that the brake disc is effectively dissipating the convection heat generated while braking and the problem that may be faced while braking or after braking due to heat. The boundary conditions applied for analysis of brake disc are convection, heat flux, radiation. This gave result for temperature.

The formula to calculate the pressure:

$$\text{Force} = \text{Pressure} * \text{Area}$$

The SI unit is $\text{N} (\text{kg} * \text{m} / \text{Sec}^2)$

$$\text{Formula for heat flux: } Q = k * A * (T_{\text{hot}} - T_{\text{cold}}) / d$$

Q-Heat flux

k-coefficient of conductivity

A-Area of Cross-section

T_{hot} -Temperature after clamping

T_{cold} . Initial Temperature

d-Diameter of Disc

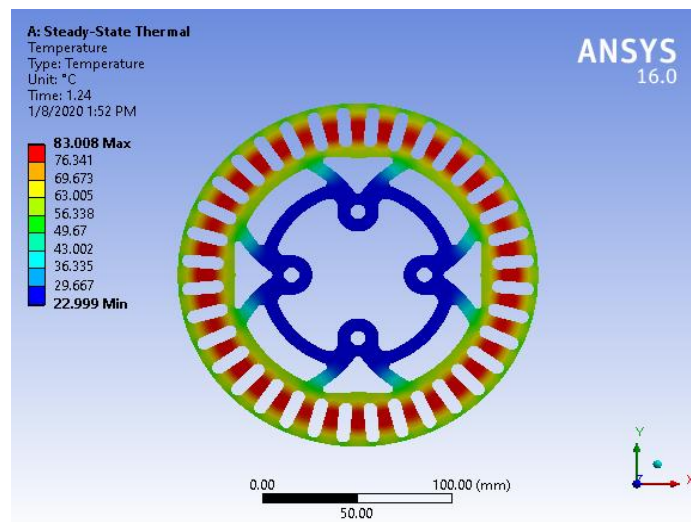


FIGURE 2: Steady State-Thermal Analysis of Brake Disc

4.1.3 Static Structural: The static structural is one of the effective ways to determine the effects of the model that is designed and it also helps to determine the forces, damping forces etc. on the surfaces that induced significant loads and effects acting on it. The reason to use this method for analysis of brake disc is to understand that the brake disc is strong enough that it does not break on extreme stress condition also which is generated while braking and the problem that may be faced while braking or after

braking due to stress. The boundary conditions applied for analysis of brake disc are force and momentum. This gave result for Equivalent (von-mises) Stress. The equivalent stresses

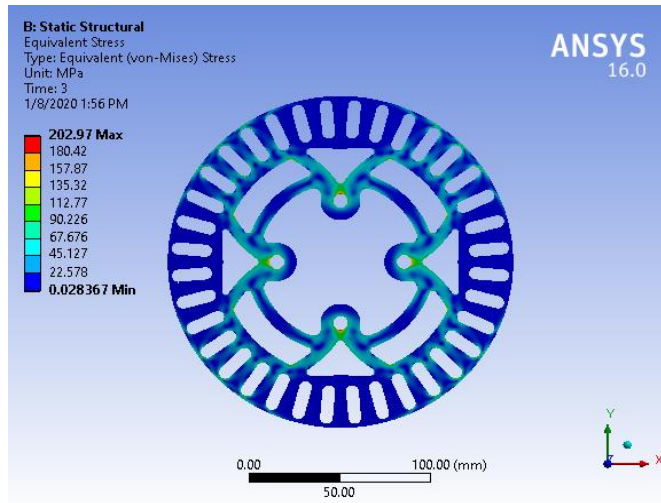


FIGURE 2: Static Structural Analysis of Brake Disc

4.1.4 Brake Pedal: The brake pedal is used to actuate the braking system and it also multiplies the force applied by the driver on the brake pedal which make the vehicle to stop efficiently with less effort for that the pedal ratio is considered. The assembly of brakes is a cantilever assembly. The brake pedal ratio considered is 6:1. The boundary condition applied for fatigue testing of brake pedal are fixed support, remote force and normal force. The force applied by the pedal on the master cylinder piston is 6 times the force applied by the driver on the foot rest of the pedal.

The length of brake pedal is decided according to space available in the vehicle. The length is also considered according to pedal ratio of the pedal. The pedal ratio also helps to find the pivot point and mounting point on the brake pedal.

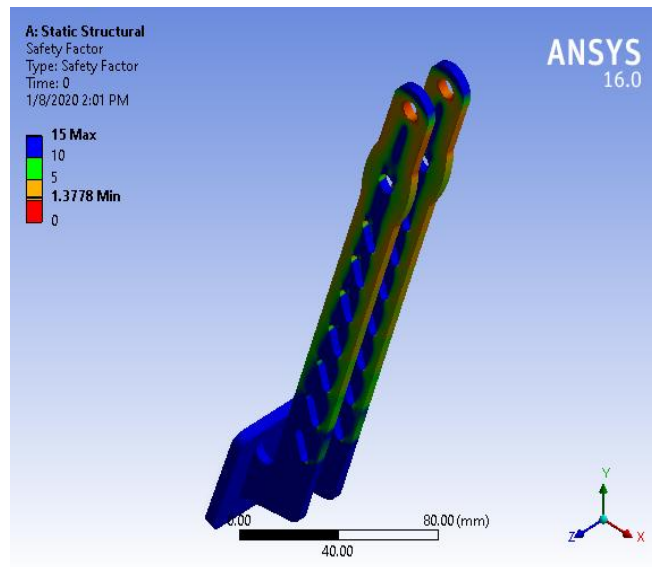


Figure 3: Factor of Safety

IV CONCLUSION

Analysis of the braking system plays an important stage as it validates the design and manufactured system to be suitable for the application in the vehicle. The approved system shows apt consideration of the parameters in which the vehicle is meant to endure. The design of this braking system is safe and is capable to stop the vehicle with locking all four wheels in shortest distance. The system designed is as safe as it can also be installed into the all terrain vehicle to lock the four wheel.

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