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Design and Analysis of Petal Brake Disc for an ATV

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Abstract - An automotive brake disc is a device for slowing or stopping the motion of wheel while it runs at certain speed. Disc brake are exposed to large thermal stresses during routine braking and during hard braking i.e. the kinetic energy of vehicle converted into mechanical energy which must be dissipated in the form of heat. This paper deals with studies about designing of model and heat generated i.e. thermal analysis and heat flux analysis. The model is done using UG NX-9.The main consideration for this disc is considering the technical aspects of all-terrain vehicle. ANSYS is mainly used for structural analysis, thermal analysis and heat flux analysis. ANSYS is general-purpose finite element analysis (FEA) software package. Finite element analysis is a numerical method of deconstructing a complex system into very small pieces of user designated size. The design requirement of petal disc is with minimum thickness, light weight, maximum heat flux and avoid critical stress area.

Key Words: QFD (Quality Functional Deployment), Heat Flux, FEA (Finite Element Analysis), PCD (Pitch Circle Diameter), ATV (All terrain Vehicle), ANSYS.

1. INTRODUCTION

The most important part of vehicle is brake system. Brakes are required to stop the vehicle within least possible distance and it is done by converting kinetic energy of the vehicle into heat energy by friction which is dissipated into atmosphere. Brakes should also be consistent with safety .The driver should have good control over the vehicle during panic braking. During the panic brake the vehicle should not skid. The brake should have proper anti fade characteristics and their effectiveness should not decrease with application. Disc brakes are widely used on cars because of their better heat dissipation ability; a direct result of the exposed friction surface.

Brake assembly consists of disc rotor that rotates the wheel, caliper assembly attached to the steering knuckle, disc pads that are mounted to the caliper assembly. This work shows a heat generation and dissipation of a disc brake of a vehicle during emergency braking and the following release period.

This study is concern with heat and temperature distribution on disc brake rotor. In this paper, finite element analysis approached has been conducted in order to identify the temperature distributions of disc brake rotor. ANSYS has been used as finite element software to perform the thermal characteristic of disc brake rotor and assist the automotive industry in developing optimum and effective disc brake rotor.

1.1 OBJECTIVES

- Best combination of parameters of disc brake rotor like profile, material and dimensions there by use of best combination to ATV.
- Better heat dissipation.
- Static Structural and steady state thermal analysis.

1.2 DESIGN RESEARCH

- Study of disc brake , material, components.
- Applying QFD for disc material.
- Design of disc brake as per calculation in NX-9.
- Analyze same model using ansys.
- Optimization of design.
- Redesign of disc.
- Define.
- Conclusion.

2. LITERATURE REVIEW

Yogesh .H.Mishra .et.al. [2] Disc profile plays an important role in thermal distribution and should be carefully selected. The result got for selected profile shows good improvement compared to other profiles. The thermo elastic phenomena occurring in the disc brake, the occupied heat conduction and elastic equation are solved with contact problems. In this research they found braking should not last longer than 10-15 sec. on the test becomes brake elements heats up to 80°C.at these higher temperature braking system and properties of brake material become worst.

Venkatraman R .et.al.[7] On the basis of the current work, it is concluded that the copper liner which dissipates the heat as grey cast iron. The cast iron has maximum temperature produced is about 603.5c without copper liner. The cast iron has the maximum temperature produced is about 335.98c with presence of copper liner can be used in brake disc which will give a moderate cooling at low temperature as compare to grey cast iron. So, it can be used in racing car where high temperature produced.

S. Sarip[8] the design of the connection between the friction ring and the hub is important in a lightweight weight brake disc. The importance of this connection has been recognized and understood for many years and car brake disc designers pay a use full attention to the design of the so-called "top hat" region of disc. However the lightweight brake disc of the type proposed here has a completely different temperature profile, both in terms of magnitude of the temperature reached during braking, and the distribution of temperature in disc. This is also known from the use of lightweight discs

on motorcycles but, again the duty level is much different. This work predicts the magnitude and distribution of temperature in a lightweight brake disc for a passenger car and consequently the expected coning.

It can be concluded that stainless steel is a suitable material for a lightweight brake in terms of mechanical and thermal strength.

3. BRAKE DISC, MATERIAL AND COMPONENTS

All terrain vehicle is design in a such a way that to overcome with every obstacle and urgent turning this all require design strong and lightweight. So, brake disc for ATV in such a way that it has lowest possible weight Which gives reduction in weight of braking system and it is compact and easy than the drum brake. Petal disc is only the type of disc which gives the required light in weight and the braking effect. Petal disc gives maximum heat dissipation.

The material which is going to select must have the high ultimate strength & yield strength with required coefficient of friction also sustain with high temperature range. Disc brake assembly consist of brake disc, disc braking element, brake pad, lever, and other parts. It would greatly increase the simulation difficulty and analysis time if including all the parts in the finite element model. Only brake disc is considered when creating model.

4. MATERIAL SELECTION

Material selection is the preliminary and important step in the designing of appropriate rotor. The selection of material basis of quality functional deployment (QFD) factor gives best suitable material for us. We have selected three materials that are cast iron, steel 416, carbon composite etc. By comparing and applying all properties consist of density, strength, thermal conductivity, young's modulus etc. to the disc and taking an iteration of analysis on disc in ansys 15.0, we get best suitable material as the steel 416. For selection of a steel 416 the factors also influences are availability, material cost, machine cost, suitable manufacturing process.

Table -1: material selection for brake disc

Properties	Cast iron	Steel 416	Carbon composites
Density (kg/m^3)	7000	6800	1800
Young's modulus (Mpa)	125	200	95
Poisson Ratio	0.25	0.30	0.31
Thermal conductivity (w/m-k)	54.5	38.7	40
Specific heat (J/Kgk)	586	460	755
Coefficient of friction	0.2	0.4	0.3

5. DESIGN CONSIDERATION

To Design a disc brake first we have to consider all hard dimensions and wheel geometry, also from the mounting point of view to know the layout of wheel assembly. the design of hub in such a way that there will be the mounting provision for the disc. The design of disc brake should be light weight as we are utilizing for an ATV. again the main thing to be consider in the designing is manufacturing process and its reliability, considering the manufacturing process is the main thing that affects on its working and running performance. The consideration of generating heat at the time of clamping the disc brake i.e. the design of disc brake gives the maximum heat dissipation in the form of radiation and convection through the disc. These all aspects possesses main role in design consideration.

5.1 DESIGN SPECIFICATION OF ROTOR

Disc dimension 160mm

Pith circle diameter (PCD) 70

Disc material Steel 416

Coefficient of friction (wet) 0.07-0.13

Coefficient of friction (dry) 0.3-0.5

Maximum temperature 340°C

6. MESHING OF DISC

The element used for meshing of the disc is tetrahedral three dimensional elements with nodes. In this stimulation, the meshing was refined in the contact zone. These are important because in this zone, temperature varies significantly.

These are why an accurate account of the contact conditions involve the use of refines mesh.

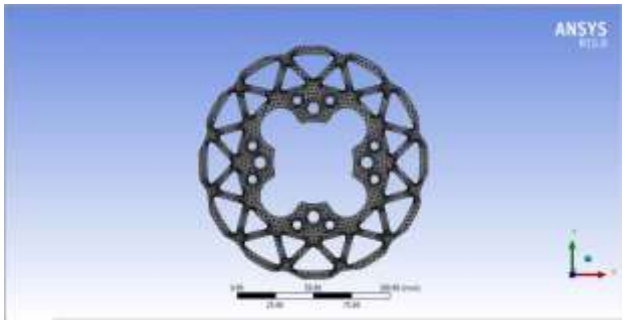

Fig-1: Meshed model of disc brake

Meshing of disc brake has been done in ansys workbench; the minimum size of element is 0.871360 mm. The complete mesh consists of 23126 elements and the number of nodes 82860.

7. ANSYS OF BRAKE DISC

7.1 STATIC STRUCTURAL ANALYSIS

Thermal behavior of brake disc of ATV is done using ansys 15.0.The modeling of temperature distribution in the disc brake is used to identify all the factors and the entering parameters concerned at the time of braking operation such as type of braking, geometry design of the disc and used material For the validation of these things ansys is required.

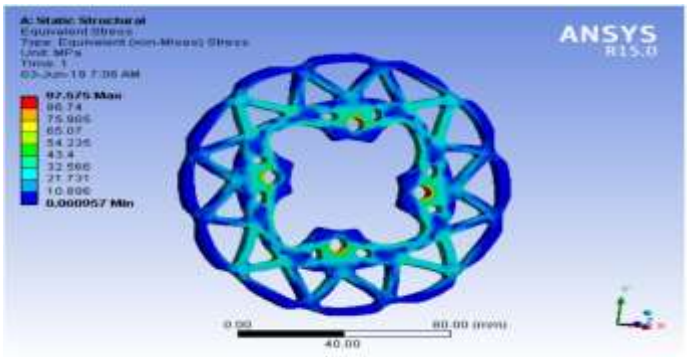

Fig-2: Ansys of static structural equivalent stress

Static Structural Analysis of disc	Total Deformation (mm)	Equivalent Stress (Mpa)
	0.0014603	97.575

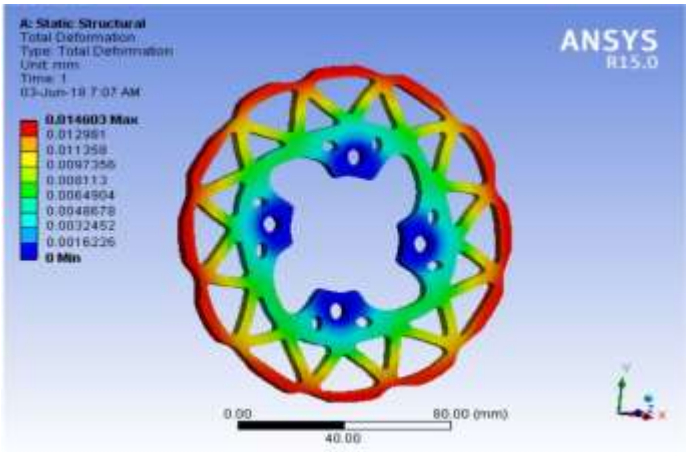

Fig-3: Ansys of static structural total deformation

7.2 STEADY STATE THERMAL ANAYSISS

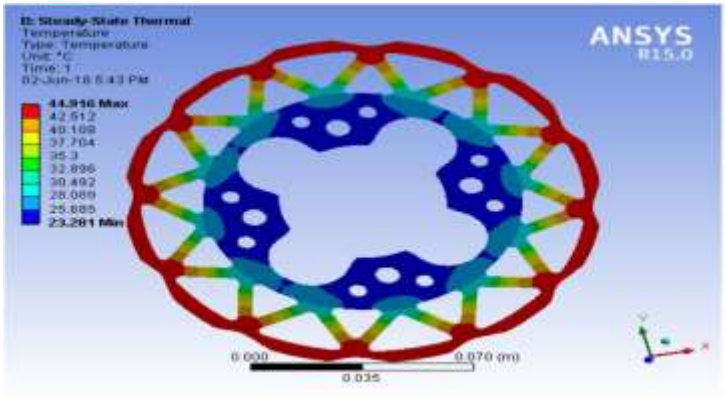

Fig-4: Steady state thermal-temperature

The analysis of disc for the generation of heat is to shown in fig 4 and fig 5. The maximum heat flux is where the maximum heat generation taken place. The heat dissipation is done in the form of radiation and convection through disc.

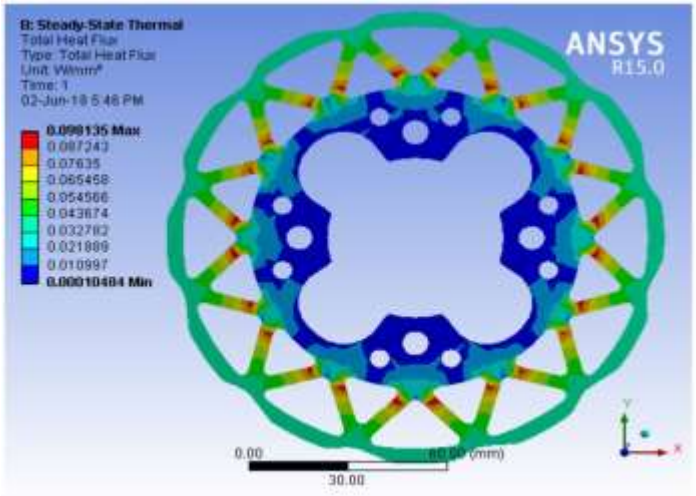

Fig-5: Steady state thermal-heat flux

Steady State Thermal	Temperature (ºC)	Heat flux (W/ mm²)
	44.916	0.098135

8. CONCLUSIONS

On the basis of current work, it can be concluded that steel 416 can provide better brake performance in the point of view thermal characteristics. This work validates steady state thermal as well as static structural analysis. The meshing of brake disc is also done in this research paper.

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