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Design Improvement and Structural Optimization of an Motorcycle Disc Brake

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Abstract: Design of a disk brake rotor is essential factor for break performance in motorcycle. In this paper a motorcycle disk brake is studied for design improvement of rotor. Optimization of rotor of disk brake is carried out using "shape optimization" tool in ANSYS 15.0. After determination of the possible area for material removal, the behavior of modified rotor design is analyzed under same boundary conditions as for previous design.

Key words: Disk Brake, Rotor, Structural Optimization, ANSYS 15.0

INTRODUCTION

Disc-style brakes use and development began in 1890s in England. The first calliper-type automobile disc brake was patented by Frederick William Lanchester in his Birmingham, UK factory in 1902 and used successfully on Lanchester cars. Since disc is more readily cooled disc brakes offer better stopping performance compared to drum brakes [1].

In disk brake hydraulic pressure is applied to the caliper piston, it forces the inside pad to exchange the disc. As the pressure rises, the caliper moves to the right and cause the outside pad to contact the disc. Braking force is produced by friction between the disc pads as they are squeezed against the disc rotor. As disc brakes do not use friction between the lining and rotor to rise braking power as drum brakes do, they are less likely to cause a pull. The friction surface is continuously exposed to the air, ensuring good heat dissipation, reducing brake fade [2].

In this paper Bajaj Pulsar 135LS disk brake is studied for design improvement. Comparing the previous and modified disk results obtained from shape optimization it is concluded that modified type disc brake is the best possible for the present application.

DISC BRAKE ROTOR

Generally, the disc rotor is made of gray cast iron, and is either solid or ventilated. The ventilated type disc rotor consists of a wider disc with cooling fins cast through the middle to ensure good cooling [3]. Proper cooling prevents fading and ensures longer pad life. Some ventilated rotors have spiral fins which create more air flow and better cooling. Spiral finned rotors are directional and fixed on a specific side of the vehicle [4]. Solid type disc rotor is found on the rear of four-wheel disc brake system and on the front of previous model vehicles.

A third style rotor can be either the ventilated or solid type which incorporates a brake drum for an internal parking brake assembly [5].

Specifications of standard disc brake rotor

In this paper studied standard of two wheeler name Bajaj Pulsar 135LS disk brake;

Rotor disc dimension = 240 mm,
Rotor disc material = Gray cast iron,
Rotor thickness = 4 mm,
Pad brake area = 2000 mm2
Pad brake material = Asbestos,
Coefficient of friction (Wet) = 0.08-0.12,
Coefficient of friction (Dry) = 0.2-0.5,
Maximum temperature = 250 ºC,
Maximum pressure = 1 MPa

DETAILS OF MODELS

Original disc brake has been 12 holes of diameter 9 mm arranged equally at pitch circle diameter (PCD) of 223 mm. There are 10 holes disc diameter 9 mm arranged equally at PCD of 189 mm. 6 cut section equally spaced as in figure 1. This rotor is to be mounted on wheel on 6 holles of 6 mm diameter at PCD of 140 mm.

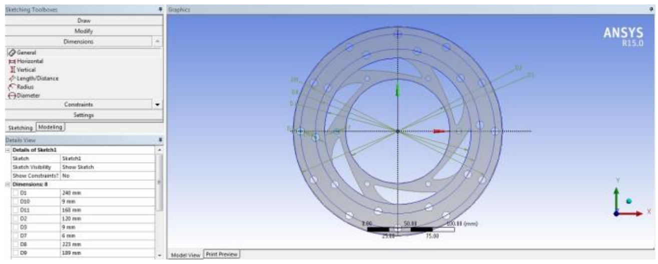

Fig 1: Dimensions of original disk brake

A disk brake rotor model is prepared using 3D CAD system: SolidWorks. This model is then imported in ANSYS 15.0 for structural optimization.

BOUNDARY CONDITIONS AND LOADING FOR STRUCTURAL OPTIMIZATION

Disk rotor is fixed on the 6 mounting holes. The moment of 10 Nmm is applied on disk axially. Material properties considered for analysis is of Grey Cast Iron.

Figure 2 shows the boundary conditions applied on the disk rotor.

Meshing

Essential subject of FEA is to make calculations at just finite number of focuses & then add the outcomes for whole area (surface or volume). While doing an analysis

Tetrahedron element type is considered with element size of 3 mm. Figure 3 gives the Geometry Details and figure 4 gives the Meshing Details.

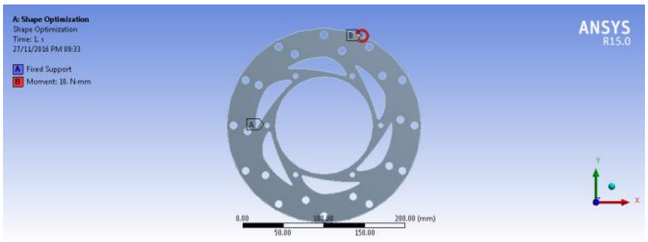

Fig 2: Boundary conditions applied on the disk rotor

Details of "Geometry"

Bounding Box	
Properties	
Volume	1.0856e+005 mm³
Mass	0.78166 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	39723
Elements	20635
Mesh Metric	None
Basic Geometry Options	
Advanced Geometry Options	

Fig 3: Geometry Details

Details of "Patch Conforming Method" - Method

Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Method	Tetrahedrons
Algorithm	Patch Conforming
Element Midside Nodes	Use Global Setting

Details of "Face Sizing 2" - Sizing

Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Suppressed	No
Type	Element Size
Element Size	3. mm
Behavior	Soft

Fig 4: Meshing Details

OPTIMIZATION

The reduction of the weight plays a particularly important role for the design of vehicle parts. However, an optimization of the weight can only be considered under the boundary condition that the lifetime of the part is reached.

Here shape optimization tool in ANSYS 15 is used and possible area for material removal is identified. Figure 5 shows the suggested area of material removal by ANSYS 15.0

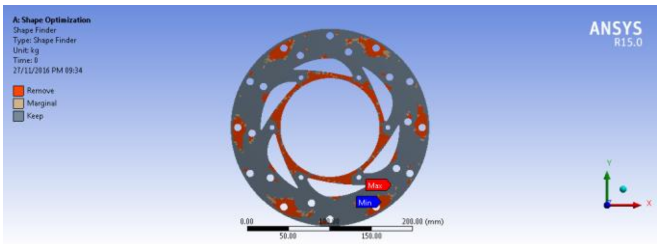

Fig 5: Shape Optimization of original disk break

The red area is the suggested area of material removal, gray area is the material to be kept. Yellow color indicates the marginal area.

Details of "Shape Finder"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Target Reduction	20. %
Suppressed	No
Results	
Original Mass	0.78363 kg
Marginal Mass	1.1442e-002 kg
Optimized Mass	0.62841 kg

Fig 6: Mass reduction achieved in modified disk rotor

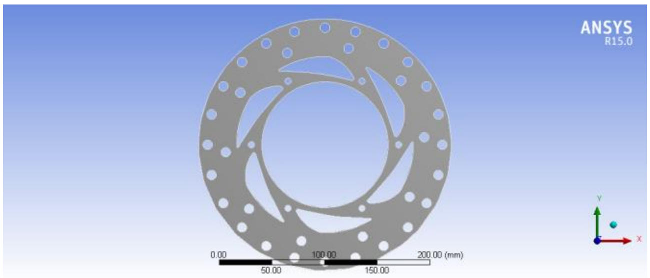

Fig 7: Modified disk rotor

With this considerations the modified geometry consist 24 holes of 9 mm arranged equally at pitch circle diameter (PCD) of 223 mm. This increased in 12 holes brings the weight reduction of 19.8% which is shown in figure 6. Figure shows the modified disk brake.

CONCLUSION

Structural optimization significantly reduces the material required in the disk brake rotor. Here 19.8% of weight reduction is achieved. This design improvement in component can be used in various ways. Firstly, the weight of the part is reduced thus the cost of production. If this significantly exceeds the design criteria, the part would be massively improved.

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