Design of Disc Brake for Bajaj Pulser 150cc

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Abstract

These day technologies go beyond us. For automotive field, the technology of engine develops very fast even the system of the car, luxury etc. which comforts everything that develops by the innovation of engineer. Although the engineer gives priority for comfort or safety measure, but most consumers still have inadequate of knowledge in safety system. During turning movement or sudden braking of any vehicle, disc rotor subjects to heat dissipation and uneven stresses which causes problem like Scarring, Cracking, Rusting, Poor stopping, noise, Vibration, Pulling, Grabbing, Dragging, Pulsation etc. which increases the chances of accidents due to poor efficiency of disc rotor. Thus, safety is the first important thing we must focus. This project "Design and Optimization of Brake Disc of Honda CB unicorn, 150cc using Finite Element Analysis (FEA)" studies about different forces acting on disc brake by analysis as well as by

designing five different profiles of disc rotors with possible optimization of material and finally selection of desirable Performance profile of disc rotor for greater efficiency. Therefore, we can estimate the efficiency of the disc brake. Hopefully this project will help everyone to understand how disc brake works more efficiently, which can help to reduce the accident that may happen in each day.

Key Words: *disc rotor, Heat flux, Stress, Design, Analysis.*

1.INTRODUCTION

In braking system one of most important active safety of vehicle. While braking, most of the kinetic energy are converted into thermal energy and increase the disc temperature. This project deals in disc brake rotor design, disc rotor profile selection, disc rotor material selection & thermal stress analysis on Honda CB Unicorn, 150cc brake disc rotor. The heat dissipated along the brake disc surface during the periodic braking via conduction, convection and radiation the findings of this research provide a useful design tool to improve the brake performance of disc brake system.

1.1 MATERIAL SELECTION FOR DISC ROTOR

Brake disc or rotor is a crucial component from safety point of view, materials used for brake systems should have stable and reliable frictional and wear properties under varying conditions of load, velocity, temperature and environment, and high durability. There are several factors to be considered when selecting a brake disc material. The most important consideration is the ability of the brake disc material to withstand high friction and less abrasive wear. Another requirement is to withstand the high temperature that evolved due to friction. Weight, manufacturing process ability and cost are also important factors those are need to be considered during the design phase. In material selection stage, the recyclability of cast iron is advantageous but the evolution of CO_2 during re-melting has to be taken in consideration. The brake disc must have enough thermal storage capacity to prevent distortion or cracking from thermal stress until the heat can be dissipated. This is not particularly important in a single stop but it is crucial in the case of repeated stops from high speed. The information on the development and application of the materials selection method for the design of automotive brake disc is discussed.

1.2 Basic Material Selection Criteria for Disc Rotor

It should have high coefficient of friction with minimum fading. In other words, the coefficient of friction should remain constant with change in temperature.
It should have low wear rate.
It should have high heat resistance.
It should have high heat dissipation capacity.
It should have adequate mechanical strength.
It should not be affected by moisture and oil

1.3 Initial Screening of Candidate Material

Gray Cast Iron:

Gray cast irons form graphite flakes during solidification. The Gray iron microstructure is due to slow solidification rates and silicon alloying that promotes graphite formation. Gray irons typically have low ductility and moderate strength, but they have high thermal conductivity and excellent vibration damping properties.

Aluminum Alloy:
Due to its lighter weight it is preferred to manufacture vehicle component such as disc rotors. It can be easily worked, rolled, forged, extracted which very important consideration for point of view of its manufacturing. It has melting point about 658.C It has high heat conductivity and also it is a good conductor of electricity It offers very good resistance to corrosion

Stainless Steel 321
Grade 321 is the grade of choice for applications in the temperature range of up to about 900°C, combining high strength, resistance to scaling and phase stability with resistance to subsequent aqueous corrosion. Like other austenitic grades, 321 and 347 have excellent forming and welding characteristics, are readily brake or roll formed and have outstanding welding characteristics. Post-weld annealing is not required. They also have excellent toughness, even down to cryogenic temperatures.

Aluminum Alloy 6061
Aluminum alloy 6061 is one of the most extensively used of the 6000 series aluminum alloys. It is a versatile heat treatable extruded alloy with medium to high strength capabilities.

Magnesium Alloy AZ63 T1
In the recent years, magnesium alloys are being used widely due to their low density, excellent damping capacity, good machinability, and high specific strength. They are the lightest commercial structural alloys in the market.

Titanium alloy (Ti-6Al-4V)
The high strength, low weight ratio and outstanding corrosion resistance inherent to titanium and its alloys has led to a wide and diversified range of successful applications which demand high levels of reliable performance in surgery and medicine as well as in aerospace, automotive, chemical plant, power generation, oil and gas extraction, sports, and other major industries.

2. DESIGN OF DISC BRAKE

In this project study standard of two-wheeler name Honda CB Unicorn, 150cc.
Rotor disc dimension Dia. = 275 mm.
(Rotor disc material = Gray cast iron)
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 (10^6 Pa)

2.1 Pad brake area
r (R1) = 125 mm and ϴ=30 for braking area)
r (R2) = 70 mm and ϴ=30 for braking area)
Area = π r2 (ϴ/360)
Breaking Area = Total area in arc (R1) – area of lower arc (R2)
Total area in arc (R1) = π r2 (ϴ/360)
Total area in arc (R1) = π 1252 (30/360)
Total area in arc (R1) = 4090.615 mm2
Total area in arc (R2) = π r2 (ϴ/360)
Total area in arc (R2) = π 702 (30/360)
Total area in arc (R2) = 1282.81 mm2
Breaking Area = Total area in arc (R1) – area of lower arc (R2)
Breaking Area= 4090.615 – 1282.81
Breaking Area= 2808 mm2=2800 mm2 (2800×10-6 m2)

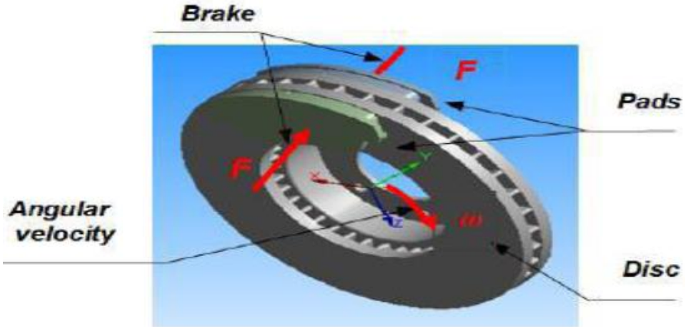

Fig. Forces act on disc brake during rotation. [2]

The above fig shows force conditions on disc brake. F (after application of brakes by hand) due to brake pad and ω is angular velocity of wheel/rotor.

2.2 Tangential force between pad and rotor. (Inner face), FTRI

FTRI = μ1FRI

Where

FTRI = Normal force between pad brake and rotor (inner)

μ1 = Coefficient of friction = 0.5

FRI = (Pmax/2) × Apad brake area

So, FTRI = μ1FRI

FTRI = (0.5) (0.5) (1×106 N/m2) (2800×10-6 m2)

FTRI = 700 N.

2.3 Tangential force between pad and rotor (outer face), FTRO

In this FTRO equal FTRI because same normal force and same material.

FTRO = FTRI = 700 N.

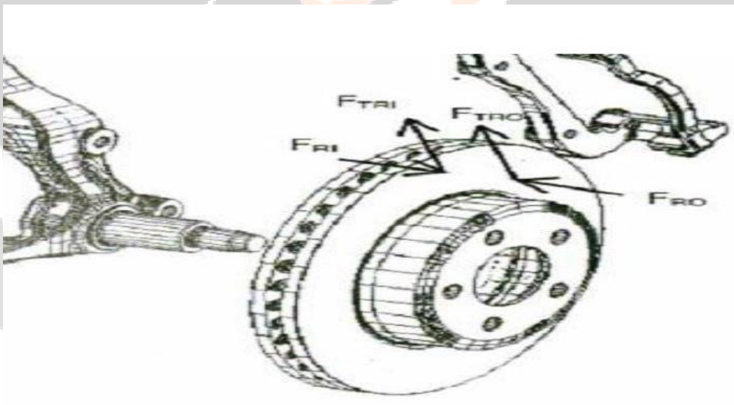

Fig. Forces act on disc brake during rotation with lever.

The above fig shows forces acting on disc brake FRI, RTRI, FTRO and FRO and their directions are as shown.

2.4 Brake torque (TB)

With the assumption of equal coefficients of friction and normal forces FR on the inner and outer faces:

TB = FT.R

Where TB = Brake torque

μ = Coefficient of friction

FT = Total normal forces on disc brake, [FTRI + FTRO]

FT = 1400 N.

R = Radius of rotor disc.

So, TB = (1400) (137.5×10-3)

TB = 192.5 Nm

2.5 Brake distance (x)

We know that tangential braking force acting at the point of contact of the brake, and

Work done=FT. x____________________________Equation 1)

Where FT = FTRI + FTRO
x = Distance travelled (in meter) by the vehicle before it come to rest.
We know kinetic energy of the vehicle.
Kinetic energy = (mv2) / 2___________________Equation 2)
Where m = Mass of vehicle
v = Velocity of vehicle
In order to bring the vehicle to rest, the work done against friction must be equal to kinetic energy of the vehicle. Therefore, equating Equation 1) and Equation 2)
FT. x = (mv2) / 2
Assumption v = 80 km/hr. = 22.22 m/s
M = 155 kg. (Dry weight)
So we get x = (mv2) / 2 FT
x = (155×22.222)/ (2×1400)
x = 27.33 m
x = 27330 mm

2.6 The Material Properties of grey Cast Iron:
Thermal co-efficient of expansion (Kxx) = 1.7039e-5 /°C
Thermal conductivity (K) = 52.0 W/ m k
Specific heat (Cp) = 586.0 J/Kg k
Density of cast iron (ρ) = 7100 kg/m3
Specific Heat Capacity = 0.46 KJ/Kg.K
Melting Temp = 1403°K
Tensile strength=137.8 MPa
Compressive strength=571.87 MPa
Poisson ratio (υ) = 0.25
Modulus of Elasticity: 110 GPa

2.7 Working stress
Factor of Safety = (Material Strength)/ (Working Stress)
Assumption FOS=2
We have, FOS=137.8/Working Stress
Working Stress=68.9 MPa.
So design is safe for Gray Cast Iron material for stress,
Stress=68.9 MPa.

3. CONCLUSIONS
Tangential force between pad and rotor (Inner Face), FTRI=700N. & Tangential Force between pad and rotor (outer face), FTRO=700N
Brake torque (TB) =192.5Nm
So design is safe for grey cast iron material for stress, stress=68.9MPa

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