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DESIGN & ANALYSIS OF INBOARD BRAKING SYSTEM

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ABSTRACT

An inboard braking system is an automobile technology where the disc brakes are attached on the chassis of the vehicle, instead of right on the wheel hubs. The benefit is a reduction in the unsprung weight of the wheel hubs, as this no longer comprises the brake discs and callipers. Inboard brakes are attached to a driven axle of the vehicle, because it requires a drive shaft to connect the wheel to the brake. Hence it has been used for rear-wheel drive cars, though four-wheel drive and few front-wheel drives have also installed them. A few rear wheel drive racing cars have also used inboard front discs, to prove the need of Inboard braking system for better performance. In this research work, maximum shear stress theory is used for design of shaft on strength basis. Material used for shaft is EN24, for disc, EN8 is used. Stress analysis of shaft and disc is executed in Ansys 14.5. Experimental testing of the conventional wheel mounted disk brake system is performed. Experimental testing of the inboard disk brake system is performed against Braking Distance, Torque, Braking Time and Brake Power Absorbed. The main objectives of this research work is to analyze the comparison of the above parameters in between conventional braking system and Inboard braking system.

Keywords- Inboard Braking, Unsprung weight, Drive shaft. Validation will be with analytical as well as experimentation with required torque and forces to rotate the cage.

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I. INTRODUCTION

Vehicle disc braking system is a type of brake that uses calipers to embrace pairs of pads against a disc in order to produce friction that retards the rotation of a shaft, such as a vehicle axle, either to decrease its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must be isolated. Hydraulic disc brakes are the most frequently used form of brake for vehicles but the principles of a disc brake are related to practically any rotating shaft.

Compared to drum brakes, disc brakes deal improved stopping performance because the disc is more readily cooled. As a consequence discs are less prone to the brake fade caused when brake components overheat. Disc brakes also recover more quickly from immersion (wet brakes are less effective than dry ones).

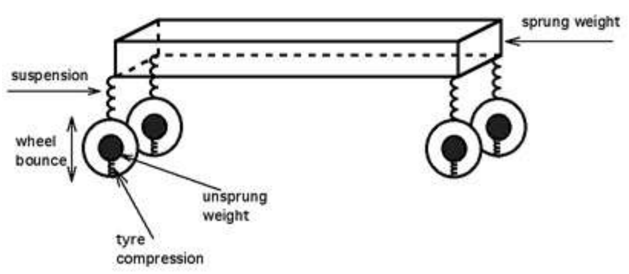
Most drum brake designs have at least one leading shoe, which gives a servo-effect. By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal, or lever. This tends to give the driver better "feel" and helps to avoid impending lockup. Drums are also prone to "bell mouthing" and trap worn lining material within the assembly, both causes of various braking
Problems

The advantage of such a system is primarily the decrease of unsprung mass; it enhances handling comfort and ride quality. The suspension doesn’t need to resist twisting when the brakes are applied by human. The wheel should not enclose the brake mechanism permitting larger flexibility in wheel offset, and placement of suspension members. It is very easier to protect the brake mechanism from the outside environment, and protect it from water, dust, and oil. It is not primary that we should address is that flexible brake pipes are to be avoided because rigid pipes allow rise in brake fluid pressure with having a small disc diameter which will attain the required pressure.

II. PROBLEM STATEMENT

Vehicle handling is the most important way that, vehicle performs transverse to their direction of motion, significantly during cornering and swerving. It also includes their directional stability when moving in steady state condition. While driving a vehicle, its handling comfort and braking performance are the most important aspects of a vehicle's "active" safety. The utmost lateral acceleration is sometimes discussed on individual basis as "road holding". (This discussion is directed at road vehicles with at least three wheels, however a number of it is going to apply to alternative ground vehicles.) Cars driven on public roads whose engineering requirements are handling over comfort as well as passengers space which has to be present in a sports car.

Solution:



This unsprung weight is supressed from bumpy road surfaces only by the compressive resilience of the tire (and wire wheels if fitted), which aids the wheel in remaining in contact with the road surface when the wheel inertia prevents close-following of the ground surface. However, the compressive action absorbed by the tire may cause rolling resistance which requires extra kinetic energy to overcome this problem, and the rolling resistance is expended in the tire as heat due to the flexing of the rubber and steel bands in the sidewalls of the tires. To reduce rolling resistance for improved fuel economy and to avoid overheating and failure of tires at high speed, tires are designed to have limited internal damping.

So the "wheel bounce" due to wheel inertia, or resonant motion of the unsprung weight moving up and down on the springiness of the tire, is only poorly damped, mainly by the dampers or shock absorbers of the suspension. For these reasons, high unsprung weight reduces road holding and increases unpredictable changes in direction on rough surfaces (as well as degrading ride comfort and increasing mechanical loads).

This vehicle unsprung weight includes both the wheels and tires, usually the brakes, plus some amount of the suspension, depending on how much of the suspension which moves with the body and how much with the wheels; for instance a solid axle is completely unsprung. The main factors that improve unsprung weight are a sprung differential (as opposed to live axle) and inboard brakes. (The De Dion tube suspension operates much as a live axle but represents an improvement because the differential is mounted to the body, hence reducing the unsprung weight) Aluminium based material will also help to achieve this problem. Magnesium alloy wheels are even lighter but corrode easily.

Advantages and Disadvantages of Disc Brakes

1) Advantages

- They are strong.
- They are little affected by wet conditions.
- They don't get clogged with mud and snow.
- They aren't affected by rim damage or out-of-true.
- They don't risk brake shoes' damaging the tire or diving under the rim and locking the wheel.
- Being external to the hub, they don't impose special lubrication requirements like a coaster brake, or risk contamination by lubricants like an integral drum brake, or overheat the hub on long, steep downhill runs.
- They also dissipate heat without overheating the tire of special importance when used as a downhill drag brake on a tandem or cargo bike.
- They don't wear rims -- especially an issue in sand and mud, or with carbon-fiber composite rims. They don't leave black dust (wear particles) on aluminum-alloy rims, to get all over your hands when you remove or replace a wheel..

2) Disadvantages

- A front disc brake stresses one blade of the front fork very heavily, requiring a stronger, heavier fork, resulting in a bumpier ride with a non-suspension fork, and if a fork isn't quite rigid enough, producing 'brake steer".
- A front disc brake caliper behind the fork blade generates a powerful force tending to loosen a quick release and pull the wheel out of the fork. Special hub and fork designs are needed to surmount this problem.
- Disc brakes are generally heavier than rim brakes.

III. LITERATURE REVIEW

Supachai Lakkam concludes that a brake disc plays an important role in the automotive industry since it concerns directly with safety. In order to develop proper heat ventilation a wide range of brake discs have been designed. To set up the experimental test for investigating the heat transfer by convection the JASO C406 standard is adopted. The experimental results in terms of heat convection coefficients are used in the numerical simulation via the finite element method in order to study the temperature diffusion and heat ventilation of front and back-vented brake discs. Consequently, the experimental results reveal that the overall heat convection coefficients of the front-vented brake disc are higher than these of the back-vented one. In other words the simulation yields that the front-vented brake disc allows stronger heat ventilation than its compared object, leading to larger temperature differences between outboard and inboard rotors, resulting in more thermal stress. This makes it more susceptible to be damaged during operation [1].

Er. N. B. Shinde, Prof. B. R. Borkar concludes that we want our vehicle's brake system to offer smooth, quiet braking capabilities under a wide range of temperature and road conditions. We don't want brake-generated noise and dust annoying us during our daily driving. To accommodate this, brake friction materials have evolved significantly over the years. They've gone from asbestos to organic to semi-metallic formulations. Each of these materials has proven to have advantages and disadvantages regarding environmental friendliness, wear and noise and stopping capability. These pads use ceramic compounds and copper fibers in place of the semi-metallic pad's steel fibers. This allows the ceramic pads to handle high brake temperatures with less heat fade, provide faster recovery after the stop, and generate less dust and wear on both the pads and rotors. And from a comfort standpoint, ceramic compounds provide much quieter braking because the ceramic compound helps dampen noise by generating a frequency beyond the human hearing range. Consequently, wheels and tires maintain a cleaner appearance longer [2]

Swapnil R. Abhang determines, Instead of having air bag, good suspension systems, good handling and safe cornering, there is one most critical system in the vehicle which is brake systems. Without brake system in the vehicle will put a passenger in unsafe position. Therefore, it is must for all vehicles to have proper brake system. In this paper carbon ceramic matrix disc brake material use for calculating normal force, shear force and piston force. Also calculating the braking distance of disc brake. The standard disc brake two wheelers model using in Ansys and done the Thermal analysis and Modal analysis also calculate the deflection and Heat flux, Temperature of disc brake model [3]

Vincent Bendix concludes that Bendix automotive businesses began producing air brakes in a small corner of the Westinghouse Union Switch and Signal Company in the early1920's. An industry trailblazer and acknowledged expert, Bendix develops and supplies leading-edge active safety technologies, energy management solutions, and air brake charging and control systems and components under the Bendix® brand name for medium- and heavy-duty trucks, tractors, trailers, buses, and other commercial vehicles throughout North America, Europe and Australia. Employing more than 2,700 people, the company is driven to deliver solutions for improved vehicle performance, safety, and overall operating cost [4].

IV. OBJECTIVES

1. Developing of disk brake, calliper and brake linkage design using theoretical formulae for conventional wheel mounted disk brake for specified unsprung mass.

2. Developing of disk brake, calliper and brake linkage design using theoretical formulae for inboard disk brake for specified unsprung mass.

3. 2-D drawing preparation (Auto-cad 2015), 3-D modelling (UG-NX-8) and analysis of system components (ANSYS Workbench-14.5) of conventional wheel mounted disk brake system.

4. 2-D drawing preparation (Auto-cad 2015), 3-D modelling (UG-NX-8) and analysis of system components (ANSYS Workbench-14.5) of inboard disk brake system.

5. Experimental testing of the conventional wheel mounted disk brake system.

To determine braking distance, Vibration (velocity and acceleration parameters—using vibrometer) and brake power absorbed at various vehicle speeds.

Graphs to be plotted

i. Braking Distance vs Speed
ii. Braking Time vs Speed
iii. Vibration vs Speed
iv. Brake Power Absorbed vs Speed

6. Experimental testing of the inboard disk brake system... To determine braking distance, Vibration (velocity and acceleration parameters—using vibrometer), and brake power absorbed at various vehicle speeds.

Graphs to be plotted

v. Braking Distance vs Speed
vi. Braking Time vs Speed
vii. Vibration vs Speed
viii. Brake Power Absorbed vs Speed

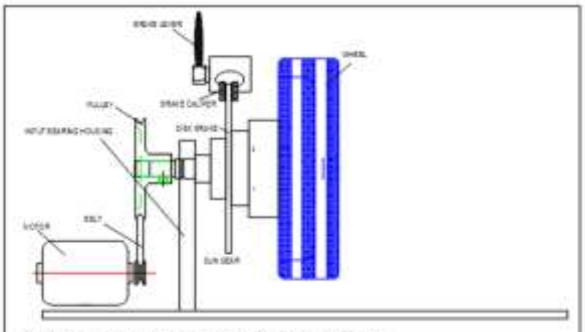
V. METHODOLOGY

1. Problem Identification through research papers and discussion forums.
    - Data collection phase involves the collection of reference material for project concept; the idea is taken from book HMT handbook.
2. Literature Review.
3. Mechanical Design of Conventional & Inboard Braking System.
4. Production Drawing and Preparation
    - Production drawings of the parts are prepared using Auto Cad, with appropriate dimensional and geometric tolerances. Raw material sizes for parts are also determined
5. Modeling of the same.
6. Analysis of Shaft, Hub & Disc.
7. Theoretical Results.
8. Experimental Results.

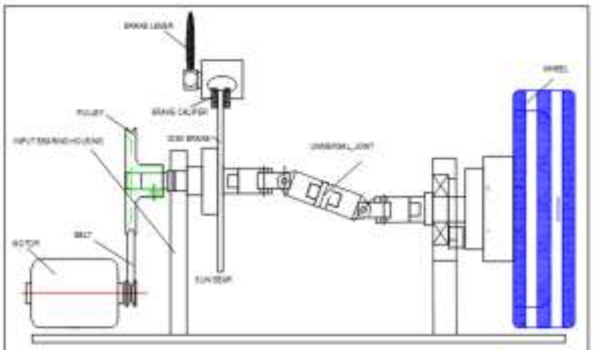
VI. EXPERIMENTATION

1. Experimental analysis of conventional braking system.
2. To determine braking distance, vibration (velocity and acceleration parameters, using vibrometer) and brake power absorbed at various vehicle speeds.
3. Graphs to be plotted

i. Braking Distance vs Speed
ii. Braking Time vs Speed
iii. Vibration vs Speed
iv. Brake Power Absorbed vs Speed



SCHEMATIC OFCONVENTIONAL DISK BRAKE SYSTEM



SCHEMATIC OFINBOARD DISK BRAKE SYSTEM

VII.RESULTS & DISCUSSION

1. Maximum and minimum braking distance with conventional and inboard braking system.
2. Maximum and minimum braking power absorbed with conventional and inboard braking system.
3. Maximum and minimum vibration velocity with conventional and inboard braking system.
4. Maximum and minimum vibration acceleration with conventional and inboard braking system.
5. Validation of the strength of critical components by ANSYS results for conventional braking system.
6. Validation of the strength of critical components by ANSYS results for inboard braking system.

Sr. No.	Load (kg)	Speed Actual	Speed Theoretical	Torque (N/m)	Braking Distance
01	0.5	826	830	0.36787	17.5
02	1	406	416	0.73575	12.2
03	1.5	265	275	1.10362	9.5
04	2	198	207	1.4715	7.2
05	2.5	159	167	1.83937	5.4

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