PERIPHERAL DISC BRAKE SYSTEM - A REVIEW

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ABSTRACT

In current days speed and torque requirement of automobiles is increasing day by day. As we know, not only speed and torque is a requirement of the automobile designers but also the braking and comfort without skidding of vehicle to avoid accidents and noise free braking is also the high priority. A capable braking system plays an essential task when vehicle has to run at superior speed. The conventional disc brake is not so much efficient to make the vehicle speed to an end within a shorter distance. The Perimeter brake design arrangement is a very efficient resolution for different vehicles. An approach to resolve the variance of the design space without disturbing the design of the wheel rim, tangential brake constructions is recommended. These are known as perimeter disc brake and discussed further in the studies.

Keywords: - *Two Wheeler Geared Vehicle, Conventional Disc Brakes, Peripheral Disc Brakes, Computational Analysis.*

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1. INTRODUCTION

In disc brake, brake calipers are used to grip pairs of pads against a disc. With the help of which friction is generated against the brake pads and the disc surface which retards the rotation of the wheel or vehicle axle, either to minimize its speed or to stop the rotations of the wheel. Compared to drum brakes, disc brakes offer better stopping capability because the braking force acts in axial direction where as drum brake braking force acts in radial direction. The heat generated due to the friction between the calipers and disc surface is dissipated quickly in the disc brake as compared to the drum brake. Even having more stopping feature as compared to drum brake, disc brake have some dis-advantages such as brake howl, break judder, breaking distance. To overcome these drawbacks, perimeter disc is one of the solutions for it.

1.1 Problems in Conventional Disc Brake

Brake Squeal:
When the brakes were applied a strident noise or high pitched squeal occurs. Most of the time, brake squeal is generated when the frequency of vibrations matches with the natural frequency of the brake components, especially the pads and discs. This type of squeal may affect negatively on brakes and consequently reduces stopping performance. In the winter due to cold weather and humidity, in early morning we observe frequently worst brake squeal, and the squeal generally stops when the brake lining or pads surface reaches regular operating temperatures. Dust particles also may cause squeal and industrial brake cleaning products are intended to remove dirt and other contaminants.

Brake Judder:
Brake judder is the vibrations experienced by the driver from negligible range to harsh vibrations which were transferred through the chassis during braking. Hot judder is usually produced due to continuous extreme braking to make the speed of the vehicle to zero or directly to stop the vehicle from a very high speed which intern transmits

harsh vibrations to the driver. These vibrations occurrence is due to uneven thermal distributions, or hot spots. Hot spots are concentrated thermal regions which is present between both sides of a disc that deform it in such a way that produces a sinusoidal waviness near its edges. When the brakes were applied and the brake pads come in contact with the sinusoidal surface, extreme vibrations are generated, and can produce unsafe conditions for the person driving the vehicle.

2. PROBLEM STATEMENT

1. For two wheeler front wheels, braking system requires large manual force to stop the vehicle. So, there is a requirement to decrease the braking force.
2. When rider applies the brake, the vehicle which is running at very high speed, it is required to stop the vehicle within a short distance which is not possible with conventional disc brake system. So there is a need to design a new brake disc system which can stop the vehicle without skidding and within a short distance.

3. OBJEVTIVES

i. Is it required to design a peripheral brake disc system and needs optimize it for the weight reduction.
ii. For the optimized peripheral disc it is required to check stresses developed at the braking load condition for the safety of the disc and the heat dissipated with the help of analysis tools such as ANSYS.
iii. Experimental testing of the conventional disk brake system is to be done to determine braking distance and brake power absorbed at various vehicle speeds.
iv. Experimental testing of the perimeter disk brake system is to be done to determine braking distance and brake power absorbed at various vehicle speeds.

4. METHODOLOGY

Step 1. Literature Review Regarding Concerned Topic: Data collection and selection of material for project from reference paper and from different technical sites.
Step 2. Component Design: In which system is design and also develop with the point of operation.
Step 3. Mechanical Design: It is related to find out what kind of forces and stress are acted on project object. The slandered parts have been selected from PSG design data handbook.
Step 4. Production Drawing Preparation: Production drawing of the parts is prepared using auto-cad and cattie v-5. With the appropriate dimension and geometric tolerance.
Step 5. Analysis of Project Model: Analysis of project model is done by using ansys-17. In which static-structural and steady-state thermal analysis is carried out.
Step 6. Material Procurement & Process Planning: Material is procured as per raw material specification and part quantity. Part process planning is done to decide the process of manufacturing and appropriate machine for the same.
Step 7. Manufacturing: Parts are produce as per the parts drawing.
Step 8. Assembly As Well, As Test & Trial: Assembly has been done according to concept and test and trial is conducted on device for evaluating performance.
Step 9. Conclusion: It include comparison of both project model i.e. existing and the new one And finally reach up to the mark that which one is the best.
Step 10. Report Preparation: Report preparation activity has been done after all above steps once carried out.

5. LITERATURE SURVEY

Shivankur Mittal, et al.[2016] It can be seen that peripheral disc brakes need lesser brake force for same end effects, induce the rest bending and shear stress in wheel spokes and lesser radial thrust at the wheel bearing. All these factors allow for a very light weight motorcycle front wheel. Lighter weight means more efficiency, reduced un-sprung mass and a higher power to weight ratio. [1]

Crowe, P, et al.[2016] The brake disc larger in diameter to provide more brake surface, cooling area and of course braking efficiency. The perimeter brakes can be very effective, much more so than small disc brakes. [2]

Heidrich, et al.[2015] In this paper author told that, the conflict of design space inside the wheel rim is the use of inside-out wheel brake constructions. These braking system is called as perimeter friction brakes. The perimeter brake concept raises questions for developers about design space integration, but even more about which fundamental operational characteristics are to be expected when brake structure and connection are changed. In the focus of this paper are properties of perimeter disc brake systems for use with during on-brake and off-brake periods, and especially investigation of scaling effects on these properties due to the principle of this brake. [3]

Manjunath T V et al.[2013] presented repetitive braking of the vehicle leads to heat generation during each baking event. Comparing the different results of temperature rise, deflection and stress field obtained from analysis it shows that in the ventilated cast iron disc reduction in temperature, stresses and deformation by 31.47 % and 22.5 % and 8% respectively than the solid disc. [4]

Li Jin et al.[2011] Brake noise is due to brake vibration during braking. If change of friction force between friction plate and brake disc is too large and fast during the braking, it can cause the brake disc and the friction plate to vibrate. When the vibration frequency up to a certain value, they will produce different brake noise. In this paper, the author considers that Brake torque variation (BTV) is the main reason about brake vibration and brake noise. He also said that, it not only just replacing the friction plate but also should change the structure design and careful selection of brake friction parts in order to minimize brake noise. [5]

Adam Adamowicz, Piotr Grzes, et al.[2010] In this paper three-dimensional finite element analysis was carried out for temperature distributions assessment in disc brake system during single braking. The disc rotor was examined without pad presence. The heat conductivity problem was divided into two cases of different configurations of the disc brake FE models owing complexity of the problem. The character of temperature evolution on the contact surface of disc and its influence in depth reveals high coincidence with regard to the three-dimensional model and simplified two-dimensional representation of the considered problem. Therefore validation of the outcomes of previously conducted study of frictional heating of disc with uniformly distributed heat flux has been made. [6]

Ji-Hoon Choi, et al.[2003] In this paper, the transient thermo elastic analysis of disk brakes in repeated brake applications has been performed. The finite element method is applied to the thermo elastic contact problem with frictional heat generation. To obtain the numerical simulation of thermo elastic behavior appearing in disk brakes, the coupled heat conduction and elastic equations are solved with contact problems. Also, the fully implicit scheme is used to improve the accuracy of computations in the transient analysis. Through the axi-symmetric disk brake model, the TEI phenomenon on each of the friction surfaces between the contacting bodies has been investigated. The hoop stress component in disk brakes has the largest compressive stress value and must be considered as a dominant stress component from the viewpoint of stress failure. The effects of the friction material properties on the contact ratio of friction surfaces are examined and the larger influential properties are found to be the thermal expansion coefficient and the elastic modulus. Based on these numerical results, the thermo elastic behaviors of the carbon–carbon composite disk brakes are also investigated. It is observed that the orthotropic disk brakes can provide better brake performance than the isotropic ones because of uniform and mild pressure distributions. [7]

H.S. Qi, A.J. Day et al.[2003] The experimental results confirm that the brake friction
interface temperature can be measured by an exposed thermocouple technique, and that the temperature characteristics identified from these measurements cannot be identified
by other temperature measurement techniques. Finite element simulations have predicted a correlation between the contact area ratio and the interface maximum temperature. It has been shown for the first time that the maximum temperature at the friction interface does not increase linearly with decreasing contact area ratio, but in contrast, the contact area ratio has little effect on the average pad bulk temperature. For a better understanding of friction braking and particularly friction interface effects, a direct friction interface temperature measurement technique, such as the exposed thermocouple technique used described here, should be used. The FEA approach used in this study for simulating the thermo-mechanical nature of the brake friction interface can provide insight into the tribological nature of brake friction process. [8]

Emanuele Toson, et al.[1995] A disc brake, preferably for motorcycle front Wheels, including a peripheral annular disc and arranged such that its calliper reaction passes through a fixed axle coaxial with the wheel axis. The calliper

is mounted at the end of a radial arm rigidly connected to the axle and the axle is torsionally keyed into at least one anti-rotation seat at a respective cooperating portion of the wheel support. [9]

6. THEORETICAL ANALYSIS WITH RESPECT TO ADVANTAGES AND DISADVANTAGES OF CONVENTIONAL AND PERIPHERAL DISC BRAKE SYSTEM

Brake Force

In the conventional disc brake system Disc is very small as compared to the peripheral disc brake setup. Assume that the frictional force needed to stop the vehicle is same in both the cases. Let, F_{BC} is breaking force required for conventional disc brake system, F_{BP} is breaking force required for peripheral disc brake system, r_1 is radius of conventional disc and r_2 is radius of peripheral disc.

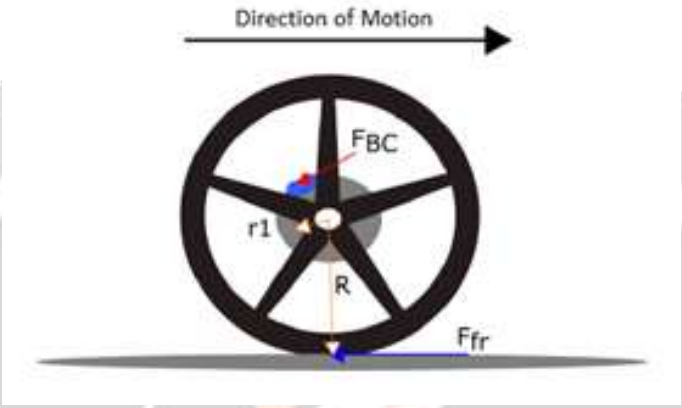

Fig. 1 Braking force on Conventional Disc

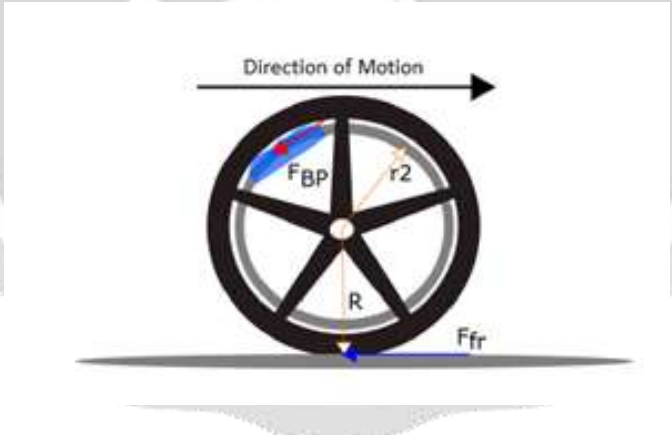

Fig. 2 Braking force on Peripheral Disc

As frictional force is same,

So, $F_{BC} \times r_1 = F_{BP} \times r_2$

And as, $r_2 > r_1$ so $F_{BP} < F_{BC}$

From the analysis, braking force required for the conventional disc is greater than the peripheral disc to stop the vehicle. From this we can say that peripheral disc is more beneficial than the conventional disc brake. For safety purpose vehicle can be stop immediately, with less braking force.

Brake force flow for spoke design

When the brakes were applied, the braking force gets transferred from brake disc to tires and road surface through the spokes.

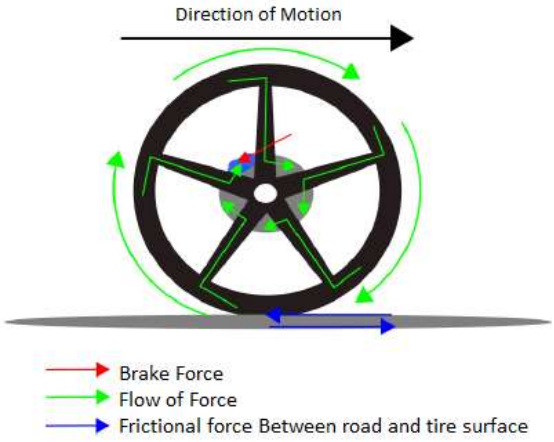

Fig. 3 Force Flow of Conventional Disc Brake

Theoretical analysis of load distribution path is carried out with the help of simple mechanics for the spokes design.

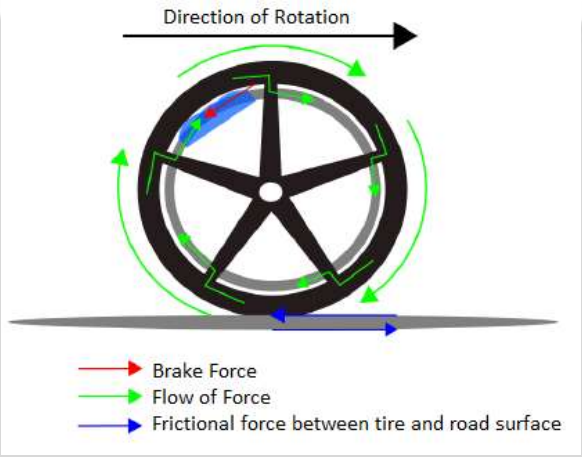

Fig. 4 Force Flow of Peripheral Disc Brake

In peripheral disc brakes, disc is attached very close to the rim, so directly the braking force is transferred to the tire without transferring the force through the spokes where as braking force gets transferred through the spokes in the conventional disc brakes. So, weight of the wheel can be optimized in the spokes where we are using the peripheral disc setup. Also in brake force flow there is no need to transfer brake force through the spokes. In peripheral disc brake disc is attached directly on the rim of tire, so after applying brake force complete periphery of the rim of tire gets brake force at a time. so vehicle can stop within a second.

7. CONCLUSION

1. From the literature review it can be concluded that the conventional disc brake system can perform braking within a short distance and time.
2. From the theoretical analysis it is found that the brake force required to stop or to minimize the speed of the wheel is less in case of the peripheral disc as compared to the conventional disc brake.
3. From the theoretical analysis it is concluded that the brake force does not passes through the wheel through spokes in case of the peripheral disc brake system. Design of the spokes can be optimized.

8. FUTURE WORK

It is required to design and optimize the perimeter disc brake system for motor cycle front wheel. To carry out the validation of the conventional and peripheral disc brake system, it is required to manufacture the experimental setup and carry out the experimentation.

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