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A Review on Analysis of Disc Brake in Automobiles

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ABSTRACT:
The braking system is the most vital system in automobiles. The brakes are used to decelerate the automobile thus reducing speed. The brakes have a caliper and a disc brake. Usually, the brake is applied on the disc brake. In that, the kinetic energy is converted to some heat. During this process, the disc brake undergoes some temperature distribution, stress distribution, heat resistance, etc. These are calculated by using FEA (Finite Element Analysis), analytical methods, and transient analysis. From the analysis, it is found that the performance and life of disc brakes depend upon the heat dissipation of cast iron, steel, aluminium metal matrix composites, etc. In that case, we can consider several materials like cast iron, ALMMC, steel, etc. Finally, we can analyze the disc brake properties and select the disc brake**.**

KEYWORDS:ANSYS, Disc brake, Thermal distribution, Stress deformation, Cast iron, Finite Element Method, Analytical Method.

I. INTRODUCTION

The first disc brake was made in 1890, and it was used in the automobile industry in 1902 in a car by Fedrick William. In today's growing automotive market, the competition for better performance vehicles is growing enormously. The racing fans involved will surely know the importance of a good brake system not only for safety but also for staying competitive. The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc, usually made of cast iron or ceramic composites including carbon, Kevlar, and silica, is connected to the wheel and the axle to stop the wheel. A friction material in the form of brake pads is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. This friction causes the disc and attached wheel to slow or stop. Generally, methodologies like regenerative braking and friction braking systems are used in a vehicle.

A friction brake generates frictional forces as two or more surfaces rub against each other to reduce movement. Based on the design configurations, vehicle friction brakes can be grouped into drum and disc brakes. If the brake disc is in a solid body, the heat transfer rate is low. The time required to cool the disc is short. If the brake disc is in a solid body, the area of contact between the disc and pads is greater. In disc brake systems, a ventilated disc is widely used in automobile braking systems for improved cooling during braking in which the area of contact between the disc and pads remains the same.

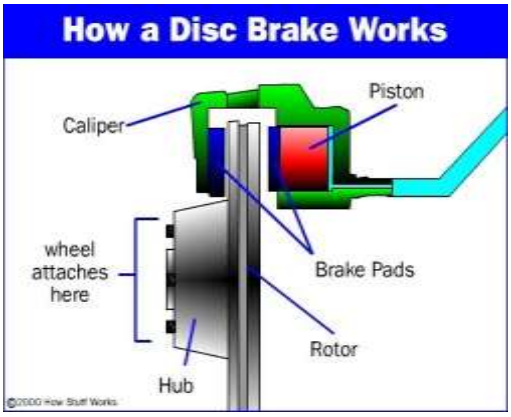

Fig 1: Disc brake

In olden days the people are used drum brakes in the drum brake When the driver steps on

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the brake pedal, the power is amplified by the brake booster and changed into hydraulic pressure by the master cylinder. The pressure reaches the brakes on the wheels via tubing filled with brake oil. The delivered pressure pushes the pistons on the brakes of the four wheels. The pistons press the brake linings, which are friction materials, against the inside surfaces of the brake drums, which rotate with the wheels. The linings are pressed onto the rotating drums, which in turn decelerate the wheels, thereby slowing them down and stopping the vehicle.

The main difference between drum brake and disc brake is that the drum brake is less efficient and when we stop the engine it takes more time, but the disc brake is more efficient and when we stop it stops fast as compared to the drum brake.

II. LITERATURE REVIEW:

Anil Babu Seelam et al [1] performed structural and thermal analysis on a 17-inch rotor disc with two different materials (stainless steel and grey cast iron). They suggested grey cast iron as the better option for discs in high-speed vehicles since it has better thermal stability.

LemiAbebe et.al [2] compared the analytical and FEM results of temperature rise, principal stress and found that these values are lower in the case of ALMMC (Aluminium metal matrix composites) compared to other materials cast iron, maraging steel and E-Glass.

Mahmood Hasan Dakhil et al [3]carriedout the design and structural analysis of disc brakesusing FEM software. They used study static structural analysisto calculate the temperature variation across the disc with the help of axis symmetric finite elements. Maximum displacement and stress are calculated by Coupled Field Analysis.

Manjunath T V et al [4] compared the performanceof solid disc brake of and the ventilated disc by computing maximum temperature and von Mises stress analytically and numerically under braking conditions. They conclude that the ventilated disc is best for application.

M. Collignon et al [5]in their paper presentedthefailure analysis of truck disc brakes numericallyand analyticallyusing the thermomechanical loading. The microcracks on the disc surface and metallurgical phase transformations were observed under a microscope.

M. Boniardi et al [6] investigated the causes of small cracks on the disc brakes of slightly used vehicles and discussed about few possible solutions to reduce those cracks. They concluded that the lifespan of brake disc depends strictly on the geometry (position of holes, shape of spokes, etc.), the material properties at high temperatures and operating conditions.

Mr. Adarsh Bhat et al [7] analysed a new design and material combination based on earlier researchers to decrease the deformation and improve thermal characteristics. They concluded that model based on material combination of aluminium, cast iron and silicon carbide the gradually increasing area of the slots on the contact region would aid better heat dissipation.

M. R. Talaee et al [8] derived an analytic solution for thermal modelling of the disc brake considering two pressure distributions in high-speed vehicles and the solution was verified for the temperature profiles of ventilated and non-ventilated disc brakes.

A. Belhocine et al [9]presented the analysis of the thermo mechanical behaviour of the dry contact between grey cast iron disc brake and pads using ANSYS and demonstrated that the ventilation system plays an important role in cooling of the disc.They showed the results of the temperature,Von Mises stress, and the totaldeformations of the disc and contact pressures of the pads increased because the thermal stresses are additional to the mechanical stresses which caused the crack propagation and fracture of the bowl and wear off the disc and pads.

M.Govindan et al [10] concluded that disc with Al/SiCMMC with 10% SiC can be used in automobiles brakes to replace conventional materials for the improved vehicle performance. They performed Finite element analysis to check the von mises stress, temperature distribution and deformation of the AL/SiC disc brake.

S. Sarip et al [11] presented the Design Development of Lightweight Disc Brake for Regenerative Braking using FEM. They suggested that the friction brakes can be downsized on a car with regenerative braking by reducing themass of the brake disc must consider temperatures, stresses, wear, deformation and durability.

Heerok Hong et al [12] simulated the braking processthrough thermal-structure linkage analysis using Abaqus/Explicit, a commercial finite element analysis program.They also analysed the thermal behaviour of the disc experimentally using an infrared camera, and the causes of the hot band and hotspot are suggested.

Masahiro Kubota et al [13]mentioned design approach for achieving an optimum thermal, vibration and weight balance of rotor disc. They calculated and compared the cooling performance,

heat resistance and noise and vibration performance of the brake rotor experimentally.

Ruoqi Suo et al [14] obtainedthe thermal elastic-plastic constitutive relation of the brake disc from experimental test, and the stress-strainresponse relationship of brake disc under different braking conditions were simulated by using the numerical calculation based on sequential coupling methodThey showed that the worst braking conditions gives the greater the temperature field and stress field.

Mohammed Asif et al [15] focussed on the design and analysis an effectivebraking system for electric solar car. A hydraulic disc brake system is designed with three-disc plates. They fabricated a working model and tested in lab and found effective in car stopping.

HyungjoSeo et al [16] conducted Brake emission teststo investigate the disc material effects on brake emission.Their results demonstrated that the brake emissions are strongly affected by disc hardness and the iron transferred to the pad surface. The transferred iron increased brake emissions due to the reduced cohesive strength of the plates on the pad surface.

Alampally Sainath et al [17] conducted the steady state thermal analysis of disc brakes using FEM. Based on the results they investigatedthe thermo elastic behaviourof the Carbon-Carbon composite, Stainless steel and Cast-iron disc brakes.They calculated Von misses' stresses and nodal stresses distribution from the structuralanalysis and compared with the existing results.

K. Sowjanya et al [18] carried the Static structural analysis by couplingthe Thermal solution to the structural analysis and observed the maximum Von Mises stressfor AlMMC rotor disc. They concluded that the Cast Iron is the best possible combination for their application.

Ashutosh Yadav et al [19] provided a design tool to improve the brake performance of disk brake system. They concluded that ventilated type disk brake is the best possible for their application. They mentioned that the Ventilated disc can be used in modern transport vehicle to improve its life cycle cost and to reduce vehicleweigh by many kilograms which is crucial point motorsport.

Avinash Singh Thakur et al [20] presented the thermal analysis of the disc brake using ANSYS. They studied many design patterns for different materials and observed the maximum temperature rise of cast iron disc is much smaller when compared to stainless steel. They concluded that the cast iron is the best desirable substantial for manufacturing disc brake.

G. Ranjith Kumar et al [21] explained the design of a straight and vented disc disc brake in solid works and hyper mesh. They concluded that the both of the brake discs are been analyzed in Ansys for the Steady Static Thermal analysis. They changing the straight vents to curved vents in the brake disc the vonmises stresses & displacement vector sum & mass of the brakes disc has been reduced. They obtain curved vented brake has high thermal flux than straight vented disc brake.

O. Maluf et al [22]conducted an experiment based on modelling in terms of low cost and speed. They calculate the component life, through finite elements, simulated the several parameters under thermal, isothermal, andthermomechanical. They can determine the isothermal, thermal and thermomechanical fatigue properties of disc brake in several temperatures of seven different gray cast iron alloys.

M Tirovie et al [23] consideredthe FEM analysis for the high performance of braking system. They created a new designextremely and high duty requirementswere developed and reduced in short time by using ANSYS software.

SnehitaKilari et al [24] evaluated the deformations and stress of the given pressure of the disc brake made up of aluminum alloy. They resolved and studied the problem in thermo mechanical disc brakes with an experimental for extension of future work.

Gongyu Pan and Rongyu Cai [25] Normally the disc brake was solid in this paper the hole is punched on the disc called ventilated disc brake. the thermostress sequential coupling based on rotating heat source is proposed, which makes the heat source rotate by invoking the subroutine that includes the mass flow rate of the disc.

V. M. M. Thilak et al [26] in this paper the analysis is the transient thermo elastic analysis. ANSYS software is applied to the thermo elastic contact problem with frictional heat generation. From that analysis they can calculate deformation, temperature, von miss stress.After applying the brake, the disc has some temperature deformation. The temperature is transfer to whole of the disc and dissipate to environment that type of transform is called transient. And also, they can calculate the structure analysis of the disc brake.

M.A. Maleque et al [27] in this paper the disc is made up of several material they can specify the method and to select the material for manufacture the disc. The digital logic method showed the highest performance index for AMC 2 material and identified as an optimum material

among the candidate materials for brake disc. n. This could be justifiable in this case as higher friction coefficient and lower density are advantageous from the technical and economical.

V. Chengal Reddy et al [28] in this paper the car disc brake was developed by FSAE and the author can analyze the disc brake in Finite element Analysis. They can calculate displacement and von miss stress in both solid and ventilated disc brake. The brake was made up of steel and the maraging steel is best material for Disc Brake.

Shaik Himam Saheb et al[29] in this journal paper the Brake performance is evaluated by the varying pedal ratios and pedal force other than standard ratio a slight variation under respective load conditions. From that they are calculating the factor of safety and stress, displacement

Mr. Sumeet Satope et al[30] in this journal paper the disc is made by cast iron and stainless steel. They can study on various design patterns for different materials of disc brake. They are calculating temperature and they can select stainless steel because of moisture is present on disc brake.

III. CONCLUSION

From the above literature of the thermal analysis and structural analysis of disc brakes made of different types of materials like aluminium, silicon, metal matrix composites, etc. trends in disc brake analysis were studied. Structure analysis means stress distribution, deformation, cracks in the disc, etc. In thermal analysis, we can see heat transfer, heat dissipation, cooling, etc. The authors say that the best material to manufacture the disc brake like the disc is light weight, more heat dissipation, wear resistance, crack resistance, long life, etc., is the best factor for disc brake. They can use ANSYS software and other software like Solid Works, etc. They can test the disc at different stages like high speed, light weight, high temperature, verity design, etc. are to test the disc.

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