ISSN No:-2456-2165

Kaunas University of Technology
Faculty of Mechanical Engineering and Design

History of Disc Brakes

VENKAT GOUTHAM USURUPATI
Project author

Prof. Sigitas Kilikevicius
Supervisor

Kaunas 2021

ISSN No:-2456-2165

Table of contents

ISSN No:-2456-2165

List of figures

ABSTRACT

Around the close of the nineteenth century, the development of a braking system for newly manufactured automobiles was necessary. This equipment, which contains several components (including the brake disc), has been developed since then. The brake system's technological progress took off with the commencement of the Second World War, in 1938, due to the necessity of the aeronautics industry.

Gray cast iron was the first material used to make brake discs because it possesses excellent thermal conductivity, corrosion resistance, low noise, low weight, long durability, constant friction, low wear rate, and a favorable price/benefit ratio. As a result, a number of materials have been developed for this purpose during the last century, but gray cast iron, which is affordable and simple to produce, is the most commonly utilized.

The modeling of fatigue strength of gray cast iron alloys is gaining a lot of attention right now in order to enhance the component's service life. Although this sort of analysis yields important results, they must be confirmed by experimental research, which implies the component must be studied in real-world rather than virtual circumstances.

CHAPTER ONE INTRODUCTION

A disc brake is a kind of brake in which the brake pads are pushed together by callipers to produce friction on the disc or rotor. This essentially interrupts A shaft's rotation to slow it down or maintain its steady rotational speed. You have to work to transfer energy from movement to waste heat. The braking rotor is known as the brake disk of a wheel (or rotor) [1]. Gray iron is a sort of cast iron, which is the material utilized in most cases. Some discs have distinct designs. Many are robust, while others are ground to include vanes or fines that link two contact sites in the surface of the disk (usually included as part of a casting process) [2] .

Johnson.et.al [3] the great majority of modern vehicle systems use front disk brakes, with the exception of four-wheel disks. When the brakes are engaged, the pads slip away from the rotor, rubbing against it. The majority of disk brakes use floating callipers. When the brakes are applied and released, the callipers glides in and out. Piston forces the inner pad into the rotor and then retracts it.

To withstand the vehicle's mass and power, the discs must be vented. To aid with heat dissipation, highly loaded front discs often include a "ventilated" design. Drums give a temporary advantage that soon diminishes if you are ascending a steep hill or doing several high-speed descents [4]. Disc brakes perform as well as their predecessors with minimum fade. Additionally, having a linear relationship between braking torque and pad/rotor friction coefficient is advantageous [5].

Modern drum brakes remain frequently used since of the rising usage of brake discs on big and heavyweight vehicles [6, 3]. Because the disk lacks self-treatment, its braking capacity is more predictable, allowing for an increase in peak braking force without danger of brake or skid [7]. The fundamental reason for the mismatch is because the vehicle's stopping distance is 150 percent of the initial distance while using drum braking. However, while using brake discs, the vehicle's stopping distance is around 120% of the original distance [8].

Johnson.et.al [9] the great majority of modern vehicle systems use front disk brakes, with the exception of four-wheel disks. When brakes remain engaged, the pads slip gone from the rotor, rubbing against it. common of disk brakes use floating callipers. When the brakes are applied and released, the callipers glides in and out. Piston forces the inner pad into the rotor and then retracts it.

Disc brakes are often needed in Europe to compensate for the higher stopping distances associated with heavier cars. Trains and certain aircraft also employ large-diameter wheels. Passenger nearly usually have discs on their wheels, allowing them to go freely [10].

A car with front disk brakes and back drum brakes This occurred in the other direction when the disc's temperature was used: as it got warmer, it grew [11]. While the disc remains is not near boiling fact, the braking efficiency remains constant. Additionally, it is quite easy to maintain: callipers are detained organised over two screws put into their holes, with the assistance of pins. Each retaining pin is Safely by a spring-loaded tension adjuster [12].

Heinz.et.al [13] it cannot be emphasized enough how important it is to incorporate use of brake discs to bring the vehicle toward a complete rest if the passenger's safety is to be ensured.

This production procedure, which resulted in Dunlop, drew much attention to manufacturing. Citroen provides front inboard ventilated and pre-heated drums as an option on their 1955 DS, whereas Triumph introduced the initial British automobile with ventilated pre-heated front discs as standard in 1956. An expansion joint, which is create on the majority Cast iron then spins are formed from brake discs at the equivalent speed as the wheel of a vehicle's braking disc.

The project's objective is to contain in depth literature survey about disc brakes in vehicle industries And various new technologies of disc brakes from modern generations are explained.

AIM:
- Literature survey of various categories of disc brakes.
- Literature survey about efficiency in disc brakes.
- literature survey about different types of materials or design in disc brakes
- Further discussions about in-depth ideas of disc brakes in future works.

CHAPTER TWO LITERATURE SURVEY

The review about various types of disc brake system is made in this present generation's, therefore it is divided in to 5 types:
- Disc
- Different kinds of venes in a disc
- Carbon Ceramics brakes
- Brake pads
- Callipers

2.1. Disc Brakes

Thom's.et.al [14] to bring the automobile to a complete rest, the disc brakes must absorb all of the energy delivered by the engine as any extra energy produced by the vehicle's motion. Once energy is diffused, it is no longer possible to concentrate it. The majority of vehicle disc brakes depend on friction to capture energy, convert it to thermal heat, and dissipate it into the surrounding air.

Limpert.et.al [15] at higher rotational speeds, where internal cooling may account for up to 50% or 60% of overall cooling, a vented and solid rotor performs better thermally. Recent work has been conducted to further enhance the venting rotor's shape

Attachment for disc brake to the axle, also known as braking rotor, so it spins as fast as the wheel. The disc frequency is well-defined by the rate of conversion of dynamic energy into heat owing toward friction forces among the pad and disc. Brake performance may be impaired if the heat isn't evacuated from the disc as quickly possible [4, 15]. Ventilation in the disc brake system, which raises the cooling frequency, is provided to provide optimal performance in demanding situations. Brake discs can be separated in two categories [16]:
1) Solid brake disc
2) Ventilated brake disc

2.1.1. Solid Brakes Disc

Solid brake discs aren't a good idea cause increased brake fade or need much higher operating temperatures. They include a better amount of metal, which supports towards stabilize temperature fluctuations then reduces the possibility of disc warping outstanding towards heat extremes [2].

Figure 1-soild disc brake

2.1.2. Ventilated Disc Brakes

Ventilated brake discs speed cooling up and hence keep the surface temperature lower. This low temperature lowers the likelihood of brake failure. fading and also contributes to reduced Wear on discs then pads. Both of these designs include or exclude a mounting bell [17]. A mounting bell lengthens the distance between friction surface and axle increases disc's surface area, which enhances cooling and so helps preserve the wheel bearings from the high temperatures produced during braking action Hybrid or composite brake disc remains multi-part disc arrangement in which the mounting bell is not included. Some authors refer to the inner ring of disc as the "braking" or "friction ring.". Here remain numerous ways to combine a mounting bell with a friction ring, the it differs on the composed of content on the disc [18, 19].

Figure 2-ventilated brake

The connecting element is a unique threaded bolt that is twisted to the mounting bell and is free to slide radially into the friction ring. This bolt is often made by steel, which may corrode, and heat may readily enter the bell. The connecting part remains of ceramic material to avoid corrosion and to decrease heat convert toward bell [19].

2.2. Straight Radial Venes

The ventilated braking disc utilized is an SRV rounded rotor with 39 valves. Numerous researches on disc brake rotor have been undertaken in current years to examine and Improve ventilation using rotors for the measurement of air velocity generated as a high-powered frequency breaker by a high-power fan. At the rotor entry and exit sites, as the interior cooling tunnels, flux parameters were collected for three typical rotational speeds. The measurements at the entrance indicated that the entrance flow was swirling then the flow was considerable [20].

Hudson.el.at [21] performed design modifications to enhance the mass flow rate of the rotor passage. Prior to further analysis, he redesigned the rotor in order to direct the flow via an inductor to introduce pre-rotation in order to prevent turbulence.

As a result, the suction side inner vane-to-vane flow separation was high, causing temperature transmittance to be inefficient. Two aspects were taken into consideration in the testing process: heat transmission and fluid movement. The internal (fins)and exterior convection (rotor surface) terms of three nominal speeds were quantified using a temporary experiment. For this experiment, power and radiation were considered unimportant [22]. The heat convector coefficients were 27,0 52,7 and 78,3 Wm-2 K-1, showing a linear linked ratio. The convection coefficients were 342, 684 and 1025 rpm. The internal convection accounted for 45.5% of total heat transfer at the slowest speed, rising to 55.4% at 1025 rpm. the radial fines' internal studies on flow were performed by channels in the experiment the phase-averaged speed field was created by using PIV. Several negative flows are present patterns, most notably fine suction side input effects and recirculation’s, have occurred [23].

According to Barigozzi.et.al [24] there are only a few earlier studies that employed hot-wire anemometry (HWA) to evaluate two disk geometries with a) backward curved and b) pedestal free flow fields at the unstable rotor exit. Both the non-dimensional mass flow and the reported turbulence strength were evidently enhanced by the pedestal design.

Johnson.et.al [25] piv was used, and a large amount of flow space was created in passageways where the radial to tangential and also radial to tangential axes exchanged air. Along with modifying the local shape of the rotor inlet, other researchers discovered that adjusting both the cross-boiled holes and the rotor inlet had an effect on cooling performance.

2.3. Curved vanes

Will wood Engineering develops and builds high quality disk braking systems. Will wood has developed a large breaker components and engineering procedures since it was established by Bill Wood in 1977. Will wood be producing approximately 120 distinct disc brake rotors in varying styles and sizes, including regular slotted then drilled, slotted designs, for road, racing and other high-performance applications. Rotors consist of high-quality ceramic-composites of steel, iron and carbon [21, 25]. A disc with curved vanes is additional operative than one with radial vanes that are straight. The disadvantage of having curved discs on right and left sides of vehicle remains that their function remains determined through the direction which the vehicle is rotated. Identification of discs is required.

Zhongzhe.Chi.et.al [26] using a heat exchanger, he studied thermal efficiency and adjusted rotor shape. The results of the FLUENT study showed that geometric characteristics in rotors influence the thermal performance of disc brakes. This geometry parameter includes both the vane angles and the van numbers. To examine the influence of vane no on the heat transmission rate, he chose five different rotors with 24,32,40,50 and 60 vans.

2.4. Pillar vanes

In actuality, the vehicle's whole energy output is transformed toward heat, which is generated on the interface disc/pad, resultant in large rise in local temperature. In many cases, more than 80% of the heat generated is absorbed by the brake disc due to the disc's cast iron and the brake pad friction material's different heat conductivity. It is crucial to thoroughly clean in order for the disc braking system to work optimally [27]. Most importantly, this achieved through airflow created by the disc's spinning. To assure optimum operation, the correct measure of heat should be dissipated. To get extra air flowing through areas, try using ventilated discs with a suitable ventilation canal width and ventilator forms that are gradually more efficient. When used on vehicles with rear or front independent axles, medium-sized or small and urban cars use the rear or front axle to offer better cooling for their solid disc brakes [28].

A.D. McPhee.et.al [29] to get more understanding of convection using brake rotor fins, they used both experimental and analytical approaches. The design of experiment used two aspects, one of which was analysing heat transfer and the other fluid motion. Internal (final) and external (rotor surface) convection conditions were measured utilizing a short-term experiment while the system was operating at three nominal velocities. Convection and radiation were seen as insignificant. To be frank, they regard just the convection. The three rotor speeds of 342, 684, and 1025 rpm yielded a fines heat transfer amount of 27,0 52,7, and 78,3 $Wm^{-2}\ K^{-1}$ that corresponded to a linear connection. 45.5% of the whole heat transfer remains provided by inner convection at a speed of 1025[rpm] and up to 55.4%.

Brembo's Pillar Venting Technology (PVT) was created years ago, and as result, it allows intended for better heat evacuation while also creating air circulation within the air chamber. By regards to the usage of this sort of technology for and vehicles exposed to severe thermal stress, it’s been increased throughout the 1990s and the present day [30].

It takes time for disc degeneration to occur as a significance of a high temperatures created during fracture, which grades in lower brake performance and increased brake pad usage. Thermal cracking resistance is increased by 40% because to PVT ventilation, which reduces brake wear and prolongs brake disc and pad life. While using T Pillar and Star Pillar patents in the vehicle sector, Brembo has continuously improved the level quality of their vented discs PVT.The solution T pillar was developed to limit particle penetration into the ventilated space of the camion brake discs, though the solution Star pillar enhances thermal fracture resistance even more [30, 29].

Belhocine Ali.et.al [31] they investigated the thermomechanical conductivity of dry connection between drive and pads during braking. ANSYS 11.0 software was used toward create the simulation. The cooling disc's ventilation system is critical. The temperature and stress fields were discovered to be completely mixed during braking. Mechanical stress from Mises' temperature, pressure, and total disc and pad contact pressures all contribute to the structure's stiffness. Altogether these factors contribute to the stiffness, resulting in crack propagation, bowl fracture, and disc and pad wear. When tension is created by heating, pressure increases.

2.5. Carbon ceramic brakes

Ceramic brakes have a high frequency of use, are very durable, and are very lightweight – all of which are critical characteristics for high-performance driving. These goods are made up of ceramic fibres, fillers, and bonders, and may include trace amounts of copper fibres. Due to the ceramic nature of these brake components, they efficiently dissipate heat and retain peak performance even after repeated hard stops. Additionally, they are less dusty than other types of brakes, and their dust is fine and not adhered to the wheels. Additionally, they generate less dust. However, they are rather expensive, and so are not suitable for many kinds of automobiles. Ceramic brakes stand frequently applied in high end cars that are driven aggressively or part of racing. Every other automobile performs well with alternate brake pad materials [18, 31].

Bu-Byoung Kang.et.al [32] to maintain low maintenance costs, new discs with greater friction and a longer service life must be manufactured. Ceramic bulk materials have a hard time withstanding cracks throughout the manufacturing process. Due to thickness of the ceramic coatings, plasma spraying used to create a scaled-down braking test base consisting of two coated brake discs then one steel disc. In terms of ceramic coating, the experiment demonstrated excellent stability at high speeds and effective braking under high friction coefficient circumstances. On the additional hand, ceramic-coated discs wore more than discs made stainless steel. In comparison, Steel Dis demonstrated variable coefficients of friction with varied driving and braking loads, resulting in reduced pad weight but increased rotor wear.

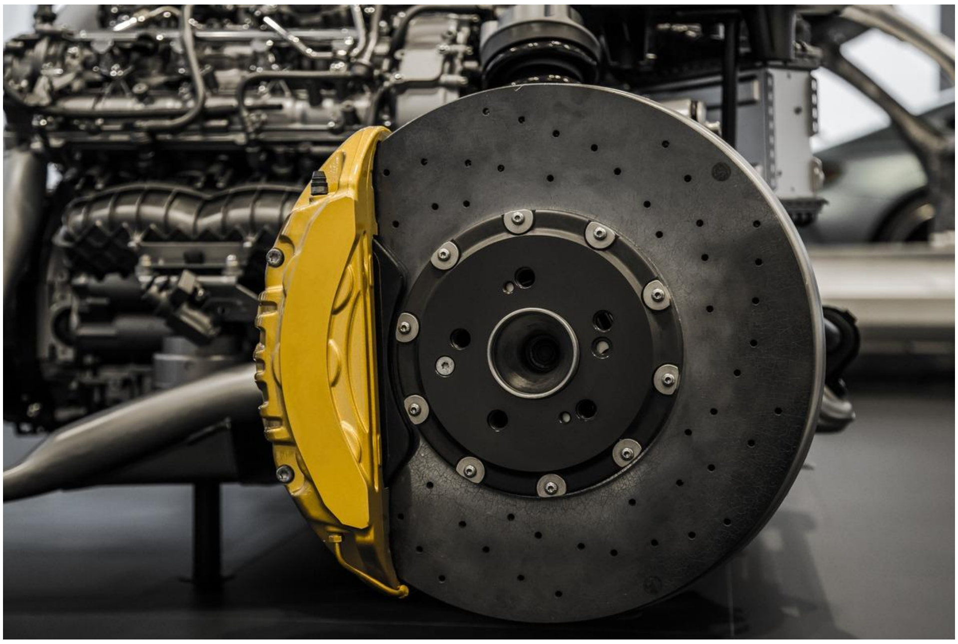

Figure 3-carbon ceramic brake

Carbon-ceramic brake are manufactured using a ceramic compound substantial that serves as a unique identifying characteristic. Carbon-reinforced silicon carbide used to make the brake's disc body as the friction layers on either side. Sic and elementary silicone remain the key of the silicon carbide matrix (Si). Carbon fibres remain incorporated into the material to reinforce it (C). Silicon carbide's principal matrix governs the composite material's extraordinary hardness. Carbon fibres provide the required strong fracture in mechanical applications while maintaining a high-level strength [32, 31].

Carbon ceramic brake manufacture process involves set up to accommodate the unique design of vehicle in three ways: using quantitative modelling, creating a prototype, and driving the automobile in the actual world. First, brake disc has to simulated mathematically using the vehicle's particular model data using a computer. Only three factors influence the disc's diameter, thickness, the friction pathway's height: they are the disc's thickness, by disc's thickness and height of the friction path. Brake construction and hub ring attachment calculations must be involved in the calculations. This remains a tough design task to handle since different thermal expansion coefficients must be accounted for at every operational temperature [24]. Additionally, the CFD model improves the system's cooling valve layout. Carbon ceramic are built out of 3D-printed prototypes, and then they are tested with real-world use to see how effective they are. From there, the design is refined in light of the results. Prototypes of the final product are tested in third and fourth phases. Furthermore, they conduct crash tests on downhill and road simulators as high-speed tests. To assess braking behaviour, such brake performance and brake comfort, the driver uses the test vehicle while conducting a series of test runs. to appearance at the findings more closely, the computer carries out a more extensive evaluation.
Liu.et.al [33] considered the properties of factors such as braking pressure, brake disc velocity, and friction issue on the system characteristics and optimized feature values to achieve the goal of removing brake screaming.

2.6. Brake pad

Swedish scholar Hammerstrom.et.al [34] patterned sandblasting on the surface of the brake discs on one hand, the roughness of surface increases; on the additional hand, the noise produced by the vehicle's braking system decreases. Friction noise is highly dependent on the friction contact parameters. Friction noise and numerous R&D activities are inextricably linked. The majority of study today focuses on the effect of frictional resistance on noise. A complete and unique research proposal has been prepared to research how a groove-shaped texture is created on a frictional surface. Even more amazing is the mix of his field of education and its imaginative character.

Kukutschova.et.al [35] if the volume of sliding changes, the degree of wear on lining will also vary. Analytical examinations revealed that the frictional layer on brake lining was chipped and deteriorated. Additionally, wear particles such as brake dust and pad wear waste were investigated, and the wear waste produced by semi-metallic pads included a variety of carbon-based elements, oxygen, aluminium, magnesium, sulphur, silicone, barium, antimony, iron, calcium, potassium, zirconium, and bromine.

Kumar.et.al [36] a novel test approach has been developed to demonstrate the influence of metal additions on the frictional and mechanical properties of braking materials. The composites studied revealed increased friction then wear properties, which were credited to the inclusion of metal. Common brake pad components include reinforcement, fillers, and organic dust, all of which have a substantial effect on the pad's strength, stiffness, and thermal stability.

Brake pad is a substantial that generates friction when it comes into contact through a sloping rear plate. brake pad for a rear plate. At times, pad is mentioned to as a mixture of friction substantial and the rear plate. A brake pad's face often has slots and chamfered edges. Numerous pad combinations available. A pad may be oriented in any orientation and may have many slots. Chamfers and slots remain used to minimize squeaking sounds. Among them is pad surface is significantly higher than pad interior, causing the pad to flex convexly. A slot may assist in flexing the substantial and preventing fractures. Additionally, dust that accumulates between the disc and surfaces of pad may be removed by permitting an outlet. The inside concept is described into 4 main types of pads [34]:

1) Underlayer
2) Shims
3) Back Plate
4) Friction material

2.6.1. Underlayer

The majority of automotive and commercial vehicle brake pads include a base Between the friction substance and the stain plate, layer. This layer ensures that the rear plate is sturdy, absorbs Vibration and noise, and stops the brake from rusting. the chemicals used in basement might potentially save money [34].

Yusli.et.al [37] a manufacturer of brake pad roughness materials has revealed insights about their polvo metallurgical pad friction material manufacturing process. It was shown that SEM was utilized to determine the morphology of models. The mixing of varied microstructures demonstrates a heterogeneous mix, which is a result of the complex composite manufacturing process.

Sugözü.et.al [34] a layer of friction was reported to be formed when two surfaces rubbed together. Responsibilities of the frictional layer may vary according on the qualities and qualities of the brake shoes then disc, the braking conditions, and the surrounding environment.

Despite its critical significance, pads are frequently undervalued and depreciated. Development has proceeded at a steady pace, although performance and security are essential to the remainder of braking system. Lapinus mineral fibres, as friction substance on brake pad, may form the fundamental component. Mineral fibres are typically composed of between 0% and 15% of the weight composition of brake pad composition (Non-Asbestos Organic Brake Pad compositions). The sub-layer may reach up to 40 percent.

2.6.2. Shims

To avoid and decrease the vibrating forces of the brakes, brake shims are utilized. The damping substance is involved to assembling pad. To further reduce vibration, shims serve as braking weight and help soften vibration pads and callipers. To assist in providing a consistent break torque and maintaining a consistent the pad's temperature, shims might be used. components pad damped with high-quality dampening material Braking system engineers alter the brake layers to optimize NVH characteristics. Without contacting the shim, pad will not do its purpose [25, 33].

2.6.3. Back plate

Brake pads lasted around 40,000 miles, dependent on braking habits and field conditions. However, this remains non for the better, but for the worst. Recent testing has exposed that the brakes do not perform as well as they should. According to Frost and Sullivan research groups, brakes are replaced 34% more often than they should be. The Global Brake Safety Council's field study corroborates this finding (GBSC). These findings demonstrate that many brake pads fail due to poor quality steel rear pads before the friction substance is depleted [14].

Verma.et.al [38] the mechanism of wear was studied, as was fragment generation on disc system. They noticed that copper-enhanced brake pads produced higher tribological coating then wear remains throughout this trial. The deformation of the secondary plateaus dictated oxidation and the tribology system's adherence to all of the wear techniques and associated wear pieces.

Press and retain the brake rotor flat across the whole friction material, pad rear plate is employed. Plate rigidity is essential. back plate must be preserved to prevent abutment areas from wearing smoothly and slipping into the antitasp clips during flat operation. Additionally, back plate aids in heat dissipation of the roughness compound. Additionally, the rear board must resist corrosion and maintain an adhesive bond for the duration of the roughness substance's and plate's life. Each braking system has a critical component.

2.6.4. Friction material

The vast majority of braking system remains made up for friction materials, since brakes need friction to stop (decelerate and stop). There are ten to twenty essential elements that combine to form brake pads, which remain of a single kind. Achieving an accurate combination of proper materials demands a high degree of skill, which incorporates cutting-edge technology. Additionally, the friction-resistance quality might also varies founded on the production technique. Over time, the technological innovations have been built upon and improved [5].

Newcomb.et.al [26] different thermal characteristics have been investigated for several rotor materials, including can't iron, metal, bronze aluminium, and dialuminium. Temperature differences between different alloys may be estimated using these formulae. Between these four materials and the aluminium rotor's maximum temperature, the steel rotor has the lowest temperature. However, the price of the steel rotor will be greater, necessitating the usage of cast iron. While the wear resistance is satisfactory, the researchers covered the cast iron rotor with a wear-resistant coating to increase its resistance to wear.

Ten to twenty kinds of raw materials are making disc brake pads, drum brake linings are made. After these resources consume remained categorized based on their particular roles, they are split into three independent groups: "bonding" and "stiffening" as "frozen material adjustment." the connections turn raw ingredients into solid products and increase their intensity Phenol resin is now the primary way of using phenol resin. Friction increases with addition of stiffener. Besides aramid, metal, and inorganic fibres, there are other forms of biofibres, including aramid, metal, and other inorganic fibres. Most importantly, friction material modification alters the efficiency of friction material. Friction materials performance may be improved by claim of this agent. Mix-and-match components such as lubricants, organic and inorganic pitches, abrasives, and metal powder are added as required [35].

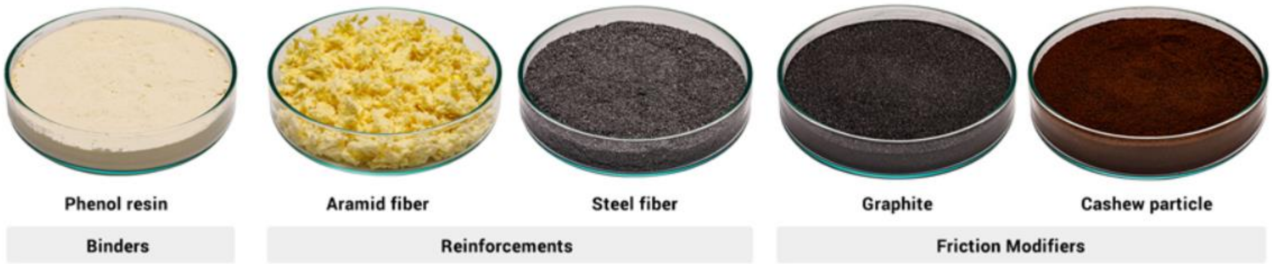

Figure 4-raw materials

Choi and Lee.et.al [39] finite element analysis investigating the transient thermal elastic properties of discs. In the transient investigation, the finite element approach was active to model thermally elastic brake contact concerns that included frictional heat production. To examine the thermoelastic phenomena associated with disc splits, the combined heat conduction and lashing equations (in cylindrical dimensions) are solved by means of a interaction problem. The wear and tear on this carbon composite material is negligible, as is its carbon impact. The thermoelastic performance of the disk brake is numerically modelled during repeated braking. Calculations of pressure and temperature distributions for each interacting entity on each friction surface are presented.

JIANG LAN.et.al [5] presented paper on thermal analysis for brake disk of Al/6061 Sci The heat and stress properties of the SiCn/Al brake disc were investigated using a finite element and calculative fluid dynamic technique during emergency braking at speeds of 300 km/h. All three mechanisms of heat transfer, convective, and radiative, have been investigated. The maximum temperature measured after activating the emergency brake was 461°C, whereas the temperature without any airflow cooling was 359°C. The similar stress would be about 269 MPa without airflow cooling and 164 MPa with it.

Eyre.et.al [18] it was discovered that when ductile iron and flaky cast iron were subjected to mild wear, the wear scar included 90% of the scar area covered by the red or black protective layer. This black-and-white advertising is quite visible. The crimson coating is easily pulverized and peeled.

2.7. Depending on the Mechanism of Action brake callipers:

1) Floating callipers
2) Fixed callipers

2.7.1. Float Calliper

A piston is put within a cylindrical, floating cell of a callipers and the cylindrical cylinder stick is connected by a guiding pin. The pin guides the callipers in a linear way along the axis. The braking rotor remains straight while the pads are off. When the brakes are functional is pressed, pressure is exerted to the column back, pressing the frozen pads in connection by the rotor callipers are forced to move along the pin, gripping the rotor by way of a result of the response [40].

2.7.2. Fixed Calliper

Fixed calliper's have rotor pistons on both sides and are suitable for direct mounting to uprights. pads are pressed onto brake rotor by pistons on equally sides. No extra bracket is required for sliding with a fixed calliper. The primary advantage of a fixed square over a floating square is the pads wear uniformly [40].

2.8. Brake callipers

Figure 5-calipers

Friction pads on callipers provide the final force applied to brake rotor. Slow car, pressure is applied to rear of a piston, causing friction among brake rotor and piston. Brake callipers are generally held upright while the fixing force is applied to piston and friction pads are installed. To provide uniform wear and heat dissipation throughout the pads, pressure distribution between them must be constant. Brake Torque is critical for braking; it should be extra than torque necessary to bring the vehicle to a complete rest. As the frequency rotor is torqued, reactive forces are imparted to callipers body, resulting in stress [13]. Once the clamping force is exerted, the rotors and pads disperse the friction and heat, resulting in a hot car.

Kazuhisa and Buckley.et.al [18] the tensile, shear, and shear forces of metals were measured and their ratios determined in order to estimate their coefficients of friction. The quantity of friction reduces as strength of metal rises.

Faiz Ahmed.et.al [33] aluminium matrix composites are renowned for their excellent strength-to-weight ratio and tolerance to extreme temperatures. The wear behaviour of alumina particle matter was investigated in this article. It was shown that alumina particle matter improves the wear properties of an aluminium matrix and brake disk composite. Around 30% of the weight of alumina is made up of alumina particles. The wear rate was 25, 50, 70, and 100 N for a certain RPM, and 250, 500, 750, and 1000 N for each additional RPM. Friction coefficient measurements have been made on both AMCs and brake discs.

Aranganathan.et.al [31] polyamide and aramid fibres contributed significantly to the friction and wear attributes of non-asbestos organic friction composites, resulting in a stable friction coefficient, excellent wear resistance, and high mechanical resistance.

Has possible toward transfer heat after the callipers body to the pads through brake pad thermal deformation. The component of brake caliper are as follows [24]:
1) Caliper body
2) Piston
3) Scapper seal
4) Bleed port

2.8.1. Caliper Body
brake caliper or a two-section caliper with a single piece body is feasible. Calipers provide a basic issue in that deflect when clamping force is applied and are finished in two portions. To minimize piston deflection, these bolts must be positioned to piston’s centreline. To be sufficiently powerful to withstand forces both within and outside the monobloc, i.e., the connection between two, you must utilize a monobloc calibre. The vertical centre of machining (VMC) and cast or vertical machine are two most often utilized processes in brake caliper manufacture (VMM). Split calipers are often easier to manufacture than monobloc calipers, since they are composed of two distinct components be machined or fitted independently and connected or detached through a bolt supply.

Farias.et.al [35] use softer, lighter, and heat-resistant calipers wherever possible. Brake calipers need a suitable amount of stress and deflection under a variety of loading conditions. Fractures in the squatting position may cause rapid leakage of braking fluid, resulting in brake failure. Due to its high-grade sturdiness, it applies constant pressure to the brake system, resulting in a short pedal action, a smoother ride, and increased vehicle safety.

2.8.2. Piston

Number of pistons in caliper has a big impact on its performance. Calipers be completed with single or many pistons, depending of the torque requirements and available space. For vehicles with reduced braking torque, a single piston be used. While torque requirement grows, bore diameter of caliper grows dramatically. That is your exact specification. In response, number of pistons must be two or three. There is just one disadvantage of using two or three double or triple piston gauges: number of leakage sources [24].

Singh.et.al [41] the effects of querastonite and composites covering querastonite, brake friction were investigated, how they changed according to physical, mechanical, tribological features. To determine if powdered willastonite enhances the friction factor, the researchers placed some powdered willastonite on a friction plate. Nonetheless, deliberate and spontaneous forces increased the wear of the complex brake friction. Additionally, willastonite fiber was employed to cut the density and hardness of material.

By putting apply pressure on the pads, you're attempting to spin the rotor. Heating causes increased wear in the leading a result of friction pad's increased heat generated. The wear pattern on friction pad of a single piston caliper is least uneven, making it less vulnerable to uneven wear across the friction. Small adjustments to the piston's movement may also beneficial. In calipers with many pistons, the pad area wears unevenly to pad area's size varying substantially along the disc circumference. Multipiston calipers include pistons of varying diameters, with the smallest located just front of piston [30].

2.8.3. Seal

After releasing the piston glides from the brake rotor surface, thereby eliminating piston drag. Make certain that no fluid is leaking. Once pedal is depressed, a gap of 0.006 inches remains. Apart from retracting pistons, the dental screen has another purpose. The piston is now in position, stretching and storing the energy. When pulled back, the piston immediately releases the energy. The fact is, degree of retraction is depending on seal deformity demonstrates the importance of considering the seal deformity when choosing a sealing groove. Drag and piston drag are inversely proportional, reduction in piston retraction results in increase drag. When the retraction is not excessive, there is some piston drag. Brakes are released, residual brake rotor torque generates piston drag. As drag grows, quantity of fuel and energy waste. More retract piston size leads in increased piston movement, which increases block stopping distance. Additionally, the pedal responsiveness is excellent (feel) [28].

Diameter of inner seal is smaller than diameter of outer seal, which is required in giving the required radial pressure. this case, the seal distortion on front corner is referred to “champagne." On front of the scrapper screw, an extra groove prevents dirt from entering the bore. A radial squeeze of around 12% to 18% is performed [19].

2.8.4. Bleed Port

Bleeding is the procedure of eliminating any trapped air bubbles from brake lines by forcing fluid through them (pipes and hoses containing brake flow). the compressibility, air bubbles and the incompressibility of brake fluid, presence for air bubbles within the brake system can significantly reduce in hydraulic stress within the system. When old fluid is replaced with new, sterile fluid, the same bleeding techniques are used [35].

Hee and Filip.et.al [35] although several publications have been published on friction process, students of brake lining materials assert that the phenomena are still not completely understood. Understanding frictional performance is difficult to mechanical-chemical reactions that occur when a composite friction material comes in contact with friction surface. The researchers observed that lining materials containing potassium titanate considerably improved friction coefficient, fading resistance, and wear strength.

Sudin.et.al [42, 43] vehicle size reduction, use of lightweight production materials, and elimination of superfluous materials from vehicle components. SolidWorks developed new design ideas for level One calipers by examining ISR commercial calipers. The objective at the moment is to minimize or reduce the caliper's size. Numerous design concepts have been established and shown in relation to the early ISR calipers, their component weight reductions, and their overall interaction with the vehicle's rim and wheels.

2.9. Survey Literature Review

In present generation the brakes or brake system are upgrading a lot. What I understood with all research currently undergoing in various fields of brakes or braking systems to take a different level in future with a new technology in electro mechanical braking.

We must explore at zero drag in future. Common brakes do not give zero drag, since they are always left with a little drag. I believe that not just for the existing ESPs that we now know, the next step will be actual individual braking. Torque vectoring, particularly in electric cars, will also be the future. I think we need incredibly fast-activating components for it. The decrease in turning time is highly essential when firms like Bosch and Continental showed their new brake boosters. They are delighted to deliver replies in less than a hundred twenty milliseconds. The is a lovely age, but with electric-mechanical brakes, that age may be obliterated entirely. When electric motor and generator are joined, the regenerative motor/breakage generators also vary significantly.

ISSN No:-2456-2165

It's not as straightforward as it seems, since we also need properly setup software. We need systems that can operate in unison. Following that, we will confront a dilemma that we must be aware of: in the future, brakes will operate without use of vacuum as a cause of energy. electromechanical brakes are critical to me. "Conti, Bosch, and TRW are all moving in the correct direction at the moment.

My viewpoint is that there are at least two major reasons for the delay. Safety and reliability are crucial; thus, the electronic braking system not be used until after the system has shown to be dependable and safe. The causes are that. Development expenses are second in importance. As with previous braking systems, at least several hundred million euros in new expenditures are necessary for the production lines of a new braking system, and because of this, for example Bosch, Continental and TRW are introducing bridge technology in their brake boosters. The bridge technologies are the brake boosters, and I believe that wholeheartedly. Their electro-mechanical braking technologies will be shown in the future.

Future research on this subject is anticipated to result in several further comparison experiments on brake operation and life under comparable stress conditions using a variety of materials. In the event of a significant alteration, this research would provide insight into the braking system's future.

ISSN No:-2456-2165

CHAPTER THREE CONCLUSION

1) Most people now realize brakes are needed on vehicles since they save lives. More so than cars, braking systems like those on planes are widely used. Braking system technology will improve in the future. While understanding certain basic fundamentals and concepts is critical for safe driving, it also vital for drivers to be aware of automobile braking system. important to point out that around is more pollution generated by brake use, such as particulate matter, noise, and wastes. We must prevent the brakes order to benefit the environment.
2) There remain numerous brake types, and they each have different advantages then disadvantages. When making purchasing decisions, customers must examine their driving conditions and pick the most suitable components. New materials may help lower number of particles and noise in future. It's possible that the electric car has a bigger market share.
3) The maximum important system that needed to be investigated and assessed, seeking enhance the car's braking performance. If it's not, brakes on automobiles that are using drum brakes on back axle will not able to keep up, since the energy generating zones are closed off and thermal energy is not removed. Corrosion, crevice, and heat loss all attest to this. matter of concern.
4) It is precisely of specialist software like ANSYS, SolidWorks, and CATIA that mathematical results are compared and validated by experimental discoveries that offer mathematical calculations and support them. The examination of prior research on subjects shown that quick temperature dissipation is assured according to brakes and ducts. There is confidence in the efficiency of brake systems, which has been proven via software design as a powerful tool to verify, evaluate and test disk brake systems.

REFERENCES

[1]. [1] Shah, R., Shah, C., & Thigale, S. Design and Analysis of a Hydraulic Brake Caliper. *Volume*, *8*, 33-41.
[2]. [2] Ouyang, H. (2008). RECENT STUDIES OF CAR DISC BRAKE SQUEAL. *New Research on Acoustics*, 159.
[3]. [3] Chen, F., Quaglia, R. L., & Tan, C. A. (2003). *On automotive disc brake squeal Part I: Mechanisms and causes* (No. 2003-01-0683). SAE Technical Paper.
[4]. [4] Choi, J. H., & Lee, I. (2003). Transient thermoelastic analysis of disk brakes in frictional contact. *Journal of Thermal Stresses*, *26*(3), 223-244.
[5]. [5] Eriksson, M., Bergman, F., & Jacobson, S. (1999). Surface characterisation of brake pads after running under silent and squealing conditions. *Wear*, *232*(2), 163-167.
[6]. [6] Ghesquiere, H., & Castel, L. (1991). High frequency vibrational coupling between an automobile brake-disc and pads. *Proceedings of I. Mech. E*.
[7]. [7] Hohmann, C., Schiffner, K., Oerter, K., & Reese, H. (1999). Contact analysis for drum brakes and disk brakes using ADINA. *Computers & structures*, *72*(1-3), 185-198.
[8]. [8] Samie, F., & Sheridan, D. C. (1990). Contact analysis for a passenger car disc brake. *SAE transactions*, 9-15.
[9]. [9] Tamari, J., & Doi, K. (2000). Prediciton of contact pressure of disc brake pad. *JSAE review*, *21*(1), 136-138.
[10]. [10] Tirovic, M., & Day, A. J. (1991). Disc brake interface pressure distributions. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, *205*(2), 137-146.
[11]. [11] Owen, C. (2010). Automotive Brake Systems, Classroom Manual.
[12]. [12] Keller, H. (2011). *U.S. Patent No. 7,967,115*. Washington, DC: U.S. Patent and Trademark Office.
[13]. [13] Giorgetti, A. (2000). *U.S. Patent No. 6,152,270*. Washington, DC: U.S. Patent and Trademark Office.
[14]. [14] Deichmann, T., & Lathwesen, H. (2012). Sheet cast disc-brake disc innovation through functional integration. *Proceedings of the Eurobrake*, 16-18.
[15]. [15] Koetniyon, S. (2000). *Thermal stress analysis of automotive disc brakes* (Doctoral dissertation, University of Leeds).
[16]. [16] Koetniyom, S., Brooks, P. C., & Barton, D. C. (2002). The development of a material model for cast iron that can be used for brake system analysis. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, *216*(5), 349-362.
[17]. [17] Hulten, J., & Dagh, I. (2006). *U.S. Patent No. 7,097,010*. Washington, DC: U.S. Patent and Trademark Office.
[18]. [18] Matozo, L. T., Menetrier, A., & Tamagña, A. (2006). *Analysis of high damping underlayer materials for brake pads and its effects on NVH performance* (No. 2006-01-3223). SAE Technical Paper.
[19]. [19] Manual, A. D. B. (1998). The Complete Guide to the Theory and Practice of Automotive Disc Braking Systems. *Tech book Series. Haynes, Somerset*.
[20]. [20] Krenkel, W., Heidenreich, B., & Renz, R. (2002). C/C-SiC composites for advanced friction systems. *Advanced Engineering Materials*, *4*(7), 427-436.
[21]. [21] Österle, W., Dörfel, I., Prietzel, C., Rooch, H., Cristol-Bulthé, A. L., Degallaix, G., & Desplanques, Y. (2009). A comprehensive microscopic study of third body formation at the interface between a brake pad and brake disc during the final stage of a pin-on-disc test. *Wear*, *267*(5-8), 781-788.
[22]. [22] Chan, D. S. E. A., & Stachowiak, G. W. (2004). Review of automotive brake friction materials. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, *218*(9), 953-966.
[23]. [23] Kemmer, H. A. (2002). *Investigation of the friction behavior of automotive brakes through experiments and tribological modeling* (Doctoral dissertation, Universitat Paderborn).
[24]. [24] Eriksson, M., & Jacobson, S. (2000). Tribological surfaces of organic brake pads. *Tribology international*, *33*(12), 817-827.
[25]. [25] Österle, W., & Urban, I. (2004). Friction layers and friction films on PMC brake pads. *Wear*, *257*(1-2), 215-226.
[26]. [26] Thuresson, D. (2004). Influence of material properties on sliding contact braking applications. *Wear*, *257*(5-6), 451-460.
[27]. [27] Wagner, A., Spelsberg-Korspeter, G., & Hagedorn, P. (2014). Structural optimization of an asymmetric automotive brake disc with cooling channels to avoid squeal. *Journal of Sound and Vibration*, *333*(7), 1888-1898.
[28]. [28] Fieldhouse, J. D., Steel, W. P., Talbot, C. J., & Siddiqui, M. A. (2004). *Rotor asymmetry used to reduce disc brake noise* (No. 2004-01-2797). SAE Technical Paper.
[29]. [29] Chowdhary, H. V., Bajaj, A. K., & Krousgrill, C. M. (2001, September). An analytical approach to model disc brake system for squeal prediction. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. 80289, pp. 2181-2190). American Society of Mechanical Engineers.
[30]. [30] Shin, K., Brennan, M. J., Oh, J. E., & Harris, C. J. (2002). Analysis of disc brake noise using a two-degree-of-freedom model. *Journal of Sound and Vibration*, *254*(5), 837-848.
[31]. [31] Morita, K. (2003). Automotive power source in 21st century. *JSAE review*, *24*(1), 3-7.
[32]. [32] Walker, A. M., Lamperth, M. U., & Wilkins, S. (2002). On friction braking demand with regenerative braking. *SAE Transactions*, 2139-2145.

[33]. [33] Gao, H., Gao, Y., & Ehsani, M. (2001, June). A neural network based SRM drive control strategy for regenerative braking in EV and HEV. In *IEMDC 2001. IEEE International Electric Machines and Drives Conference (Cat. No. 01EX485)* (pp. 571-575). IEEE.

[34]. [34] Jianlong, Z. H. A. N. G., Chengliang, Y. I. N., & Jianwu, Z. H. A. N. G. (2009). Research on braking control system for hybrid electric vehicle with electro-mechanical hybrid brake. *J Syst Simu*, *21*(16), 5169-5174.

[35]. [35] Ji, F., & Tian, M. (2010). Research on Braking Stability of Electro-mechanical Hybrid Braking System in Electric Vehicles. *World Electric Vehicle Journal*, *4*(1), 217-223.

[36]. [36] Fujita, Y., Arai, T., & Ogura, M. (1992). *U.S. Patent No. 5,107,967*. Washington, DC: U.S. Patent and Trademark Office.

[37]. [37] Wei, Z., Xu, J., & Halim, D. (2015, October). Study of HEV electro-mechanical hybrid braking system control strategy. In *2015 IEEE Vehicle Power and Propulsion Conference (VPPC)* (pp. 1-5). IEEE.

[38]. [38] Zhou, Z., Mi, C., & Zhang, G. (2012). Integrated control of electromechanical braking and regenerative braking in plug-in hybrid electric vehicles. *International Journal of Vehicle Design*, *58*(2-4), 223-239.

[39]. [39] Gao, Y., Chu, L., & Ehsani, M. (2007, September). Design and control principles of hybrid braking system for EV, HEV and FCV. In *2007 IEEE Vehicle Power and Propulsion Conference* (pp. 384-391). IEEE.

[40]. [40] Ko, J., Lee, G., Ko, S., Ahn, S., Kim, H., Choi, S., ... & Hyun, D. (2012). *Co-operative control of regenerative braking using a front electronic wedge brake and a rear electronic mechanical brake considering the road friction characteristic* (No. 2012-01-1798). SAE Technical Paper.

[41]. [41] Shinde, N. B., & Borkar, B. R. (2015). Literature review on fem analysis of disc brake system. *International Journal Of Engineering And Computer Science*, *4*(2), 10554-10558.

[42]. [42] Sakamoto, H. (2004). Heat convection and design of brake discs. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, *218*(3), 203-212.

[43]. [43] Matsushima, T.; Masumo, H.; Ito, S.; Nishiwaki, M. FE Analysis of Low-frequency Disc. Brake Squeal (In Case of Floating Type Caliper). In Proceedings of the 4th International Colloquium, ICGI-98, Ames, IA, USA, 12–14 July 1998; p. 327, ISSN 0148-7191. [CrossRef]