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Design And Analysis of A Ventilated And Slotted Disc Brake

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Abstract:A disc brake is a wheel brake that slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers. Disk brake offer higher performance, light weight, simpler design and better resistance to water interface than drum brakes. The brake disc is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and/or the Axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced mechanically, hydraulically, pneumatically, or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade. In this project we model a disc brake using solid works design software. Then the part is imported to Ansys work bench software. Static structural and steady state thermal analysis is carried out in Ansys work bench. In static structural analysis the component is assigned with various materials at certain load. Thus the structural deformations formed due to the applied loads are studied and tabulated. In steady state thermal analysis the part is assigned with various materials and temperature loads are applied, thus the temperature distributions at applied thermal load are studied and tabulated. The material which is showing maximum performance such as low stresses and high temperature distributions in both structural and thermal wise respectively is known as the preferable material.

Keywords —SolidWorks, Ansys, disc brake

1. INTRODUCTION:

A brake is a device which is used to bring to rest or slow down a moving body. Safe operation of vehicle demands dependable brakes is required to absorb the kinetic energy of the moving parts or the potential energy of the object being lowered by host when the rate of descent is controlled. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding atmosphere to stop the vehicle, so the brake system should have following requirements:

- The brakes must be strong enough to stop the vehicle with in a minimum distance in an emergency.
- The driver must have proper control over the vehicle during braking and vehicle must not skid.
- The brakes must have well anti fade characteristics i.e. their effectiveness should not decrease with is constant prolonged application.
- The brakes should have well anti wear properties.

Fig : Disc brake

Problem Statement

Brakes are often described according to several characteristics including: Peak force – The peak force is the maximum decelerating effect that can be obtained. The peak force is often greater than the traction limit of the tires, in which case the brake can cause a wheel skid.

- Continuous power dissipation
- Smoothness
- Power
- Durability
- Weight
- Noise

2. LITERATURE SURVEY

AdriaanNeys [1], the brakes system is critical with respect to vehicle safety. One situation during which the brake system is put to the test is an Alpine descent. Such a descent causes very high brake system temperatures and may even induce brake fluid vaporization. In following report an In-Vehicle Brake System Temperature Model is developed and tested.

Abu-Bakar, Huajiang Ouyang [2], this paper studies the contact pressure distribution of a solid disc brake as a result of structural modifications. Before modifications are simulated, four different models of different degrees of complexity for contact analysis are investigated. It is shown that the contact pressure distributions obtained from these four models are quite different.

Rahim Abu-Bakar, Huajiang Ouyang [3], the detailed and refined finite element model of a real disc brake considers the surface roughness of brake pads and allows the investigation into the contact pressure distribution affected by the surface roughness and wear. It also includes transient analysis of heat transfer and its influence on the contact pressure distribution. The focus is on the numerical analysis using the finite element method.

Ali Belhocine, MostefaBouchetara [4], the objective of this study is to analyze the thermal behavior of the full and ventilated brake discs of the vehicles using computing code ANSYS. The modelling of the temperature distribution in the disc brake is used to identify all the factors, and the entering parameters concerned at the time of the braking operation such as the type of braking, the geometric design of the disc, and the used material.

3. METHOD OF ACTUATION

(a) Foot brake:

Foot brake is also called as service brake and it is operated by foot pedal.

The foot or service breaks works differently. When the power brake is applied, the force is transferred to the master cylinder.

(b) Hand brake:

Hand brake, it is also called parking brake operated by hand.

The most common use for a parking brake is to keep a vehicle motionless when it is parked. The park brake has a ratchet or other locking mechanism that will keep it engaged until manually released.

4. MODE OF OPERATION

On the basis of mode of operation mechanical brakes are five types:

- Mechanical brakes
- Hydraulic brakes
- Air brakes
- Vacuum brakes
- Electric brakes

On the basis of action on front or rear wheels

- Front-wheel breaks
- Rear-wheel brakes.

On the basis of method of application of braking contact

- Internally – expanding brakes
- Externally – contracting brakes.

5. TYPES OF BRAKES

***5.1 Disk Brakes*:**

The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers.

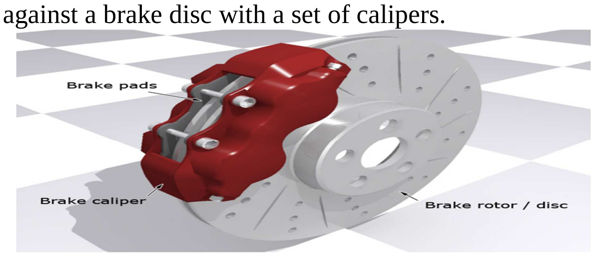


Fig.7.1: Disc brake

The brake disc (or rotor in American English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites.

5.2 Drum Brakes:

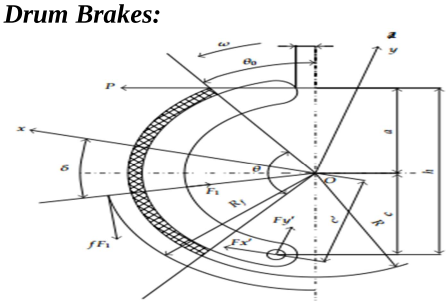


Fig.: Dimensions of shoe and liners

Drum brake is one of the most commonly used brakes in vehicle design; it can be categorized into leading- and trailing-shoe brake, two-leading-shoe brake, two-trailing-shoe brake, and servo brake concerning the arrangement of the brake shoes.

Below Figure shows the structural parameters and force diagram of the leading- and trailing-drum brake only left part of the structure is presented.

5.3 Roller brakes :

Fig: Roller brakes

Roller brakes are specially designed drum brakes for bicycles, mounted to the side of the wheel's hub.

***5.4 Parking Brakes*:**

In cars, the parking brake, also called hand brake, emergency brake, or e-brake, is a latching brake usually used to keep the vehicle stationary.

5.5 Electric Parking Brake:

A recent variation is the electric parking brake. First installed in the 2001 BMW 7 Series (E65), Electric Park brakes have since appeared in a number of vehicles.

Fig.: Electric parking brake

5.6 Anti Lock Braking System:

Anti-lock brake systems (ABS) - generally also referred to as anti-lock systems (ALS) - are designed to prevent the vehicle wheels from locking as a result of the service brake being applied with too much force, especially on slippery road surfaces. The idea is to maintain cornering forces on braked wheels to ensure that the vehicle or vehicle combination retains its driving stability and ma-noeuvrability as far as physically possible.

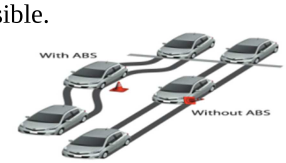


Fig.: Anti lock bra king system

Types of abs brakes are

- Four-channel, four-sensor ABS
- Three-channel, four-sensor ABS
- Three-channel, three-sensor ABS
- Two-channel, four sensors ABS
- One-channel, one-sensor ABS

5.7 Hydraulic Brakes :

The hydraulic brake is an arrangement of braking mechanism which uses brake fluid, typically containing ethylene glycol, to transfer pressure from the controlling mechanism to the braking mechanism.

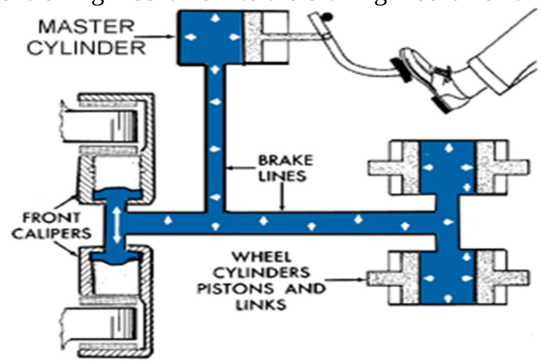


Fig : Hydraulic brake system

5.8 Electric brakes :

Electric Friction Brake, often referred to as just Electric Brake or Electric Trailer Brake is a brake controlled by an electric current and are seen on medium duty trailers like caravans/RVs and Consumer-Grade Car Trailers.

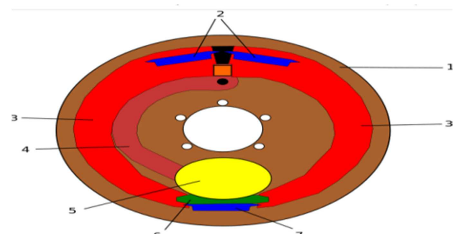


Fig : Electric Brake system

6. MATERIALS

Generally, Aluminum metal matrix composites (AMMC) with sic reinforcement is considered as a possible alternative to cast iron discs for cars mainly because of the significant reduction possible in the weight of the disc. Based on the properties we are analyzing the disc brake with similar properties:

6.1 Grey Cast Iron:

Grey Cast Iron is made by remelting pig iron. It is an alloy of Carbon and Iron. Small amounts of Silicon, Phosphorus, Manganese and Sulfur are also present in it. Its properties are as follows:

- High Compressive Strength.
- Tensile Strength.
- Resistance to Deformation.
- Low Melting Point.
- Resistance to Oxidation

Thermal Properties:

Property	Thermal Conductivity (W\mK)	Density Kg\m^3	Poissions Ratio	Young's Modulus (GPa)	Specific Heat (kJ/(kg K)
Grey Cast Iron	52	7200	0.28	110	0.46

6.2 Carbon Steel :

Carbon steel is a steel with carbon content up to 2.1% by weight. As the carbon percentage content rises, steel has the ability to become harder and stronger through heat treating; however, it becomes less ductile.

- High strength,
- Hardness,
- wear resistance,
- Moderate ductility.

Thermal Properties:

Property	Thermal Conductivity (W\mK)	Density Kg\m^3	Poissions Ratio	Young's Modulus (GPa)	Specific Heat (kJ/(kg K)
Carbon Steel	46.6	7860	0.3	2.1E+11	0.49

Structural steel :

In the Structural steel the carbon content is 0.12% max and it is a category of steel used for making materials in a variety of shapes. Its mechanical properties are

- Durability,
- Good tensile
- Yield strength
- Good thermal conductivity.

Thermal Properties :

Property	Thermal Conductivity (W\mK)	Density Kg\m^3	Poissions Ratio	Young's Modulus (GPa)	Specific Heat (kJ/(kg K))
structural steel	50.9	7850	0.3	2E+11	0.48

7. CALCULATION FOR DISC BRAKE

Design calculations for disc brake rotor

The brake pedal: The brake pedal exists to multiply the force exerted by the driver's foot. From elementary statics, the force increase will be equal to the driver's applied force multiplied by the lever ratio of the brake pedal assembly:

$Fbp = Fd \times \{L1 \div L2\}$

where,

Fbp = the force output of the brake pedal assembly

Fd = the force applied to the pedal pad by the driver = 370 N

L1 = the distance from the brake pedal arm pivot to the output rod clevis attachment

L2 = the distance from the brake pedal arm pivot to the brake pedal
pad

(L1/L2 = 4)

The Master Cylinder:

Assuming incompressible liquids and infinitely rigid hydraulic vessels, the pressure generated by the master cylinder will be equal to:

$$Pmc = Fbp/Amc$$

where,

Pmc = the hydraulic pressure generated by the master cylinder.

Amc = the effective area of the master cylinder hydraulic piston = 0.000285 m^2.

Brake fluid, brake pipes and hoses: Assuming no losses along the length of the brake lines, the pressure transmitted to the calipers will be equal to:

Pcal = Pmc

where,

Pcal = the hydraulic pressure transmitted to the caliper.

The caliper, Part I: The one-sided linear mechanical force generated by the caliper will be equal to:

$Fcal = Pcal \times Acal$

where,

Fcal = the one-sided linear mechanical force generated by the caliper.

Acal = the effective area of the caliper hydraulic piston(s) found on one half of the caliper body = 0.0007068 m^2

The caliper, Part II: The clamping force will be equal to, in theory, twice the linear mechanical force as follows:

$FClamp = Fcal \times 2$

where,

F Clamp = the clamp force generated by the caliper.

The brake pads: The clamping force causes friction which acts normal to this force and tangential to the plane of the rotor. The
friction force is given by:

$F\ friction = FClamp \times \mu bp$

F friction = the frictional force generated by the brake pads opposing the rotation of the rotor.

μbp = the coefficient of friction between the brake pad and the rotor = 0.4 (assumed).

The rotor: This torque is related to the brake pad frictional force as follows:

$Tr = Ffriction \times Reff$

where,

Tr = the torque generated by the rotor.

Reff = the effective radius (effective moment arm) of the rotor(measured from the rotor center of rotation to the center of pressure of the caliper pistons).

This torque generated by the rotor will be equal to the torque required to stop the vehicle. In this report, we have considered the Tata Vista vehicle they follow.

- Mass of the vehicle = 1140 kg.
- Maximum velocity of the vehicle = 80 km/hr or 22.22m/s.
- Stopping Distance = 17.66 m.
- Tire Size = 23 in diameter that is 584.2 mm with 7 mm thickness
- Disc flange or thickness = 16 mm.
- 50-50 wheel bias that is equal braking force is generated in all the 4 wheels of the vehicle.

- Total force generated during braking to stop the car,

F = m*a, a = deceleration during braking = $v^2/2s$ = $(22.22)^2/2 \times 17.6$ =13.97m/s²

F = 1140 x 13.97

F = 15925.8N

Torque required stopping the vehicle,

Tr = F/4 * Rw

Tr = 15925.8/4 x 0.2921

Tr = 1162.98N-m.

As mentioned in above formulae,

Brake Pedal

Fbp = Fd * (L1/L2)

Fbp = 370 x 4

Fbp = 1480 N.

Master Cylinder Pmc = Fbp/Amc

Pmc = 1480/0.000285

Pmc = 5192982.456 Pa

Amc = The effective area of the master cylinder hydraulic piston = 0.000285 m².

Brake fluid, brake pipes and hoses:

Pcal = Pmc

Pcal = Pmc = 5192982.456 Pa

The caliper, Part I: The one-sided linear mechanical force generated by the caliper will be equal to:

Fcal = Pcal x Acal

Fcal = 5192982.456 x 0.0007068

Fcal = 3670.4N

Acal = the effective area of the caliper hydraulic piston(s) found on one half of the caliper body = 0.0007068 m².

Clamping Force:

FClamp = Fcal x 2

FClamp = 2 x 3670.4

FClamp = 7340.8N

The brake pads:

Ffriction = FClamp x μbp

Ffriction = 7340.8 x 0.4 (μbp = 0.4)

Ffriction = 2936.32N

Torque Generated by the rotor during braking *Tr* = Ffriction × Reff

1163.814= 2936.32 x × Reff

Reff = 0.3963m

Thus, the Effective Rotor Radius is 0.3963 meters that is 15.2 inches or 157.5 mm. And thus, the effective diameter is 315 mm.

Based on this effective diameter, the outer diameter of the disc is decided to be 390 mm and the inner diameter to be 125 mm.

Kinetic Energy developed during braking,

KE = ½ mv²

KE = ½ x 1140 x (22.22)²

KE = 281420.4 J

Total Braking Energy/Heat required for the vehicle is equal to the total Kinetic Energy generated by the vehicle,

Thus Heat (Q) generated,

Qg = 281420.4J

Since assumption of 50-50 wheel bias is made, this heat will be equally distributed in the 4 wheels of the car, thus equally distributed in the 4 rotors. So, heat generated in 1 rotor,

Qg = 281420.4 / 4

Qg = 70355.1

Now, the stopping time of the vehicle will be velocity/deceleration,

t = v/a

t = 22.22 / 13.97

t = 1.59sec

Hence, power generated in one rotor P = Qg / t

P = 70355.1 / 1.59

P = 44248.48 watts

Thereby, we can calculate the heat flux through one disc rotor with 0.390 m outer diameter and 0.125m inner diameter.

Heat flux = 4 * P/3.14 * (Do²-Di²)

Heat flux = 4 x 44248.48 /3.14 x (0.381² – 0.125²)

Heat flux = 7694.144 Watts/m².

Calculations for heat transfer coefficient

We consider warping temperature of Gray Cast Iron to calculate the film temperature, assuming the ambient or surrounding temperature to be 300 K. Warping temperatures is the temperature at which deformation just begins and it is generally numerically equal to 70% of the melting temperature of the metal.

T_{melt} for gray cast iron = 1538°C.

T_{warp} for gray cast iron = 70% (1538)

T_{warp} for gray cast iron = 1077°C. = 1350 K

Ambient temperature = T_{amb} = 300 K.

Film temperature = $(T_{warp} + T_{amb})/2$

Film temperature = 825 K

Thus, for the required calculations for the heat transfer coefficient at the film temperature, the air properties at this film temperature, 825K or approx. 552°C. The required properties of air are summarized in the below.

Temperature (T) (°C)	552
Density (p) (kg/m3)	0.430
Absolute Viscosity (u) (Ns/m2)	37.66 x 10-6
Thermal Diffusivity (a) (m2/s)	126.96 x 10-6
Prantdl Number (Pr)	0.693
Specific Heat (Cp) (J/kg-K)	1103.5
Thermal Conductivity (k) (W/m-K)	0.059835

Table 2: Properties of air at 552°C

Relative velocity of air (v) = 22.22 m/s

Diameter of the rotor = 0.381 m

Reynold's Number, Re = (p*v*d)/u

Re = (22.22 x 0.430 x 0.390)/(37.66 x 10-6)
Re = 98945.67
Nusselt Number, Nu = 0.0266 (Re)0.805 x (Pr)0.333
Nu = 247.25
Forced Convective Heat Transfer Coefficient, h,
h = (Nu*k)/d
h = 247.25 x 0.059835/0.390
h = 38.829 Watts/m²-K

Dimensions of the Disc Plate

Brake disc diameter: 390 mm
Contact area diameter (Inner) : 149.11 mm
Contact area diameter (Outer) : 36.42 mm
Pressure applied on the disc during braking: P_{max}
Axle diameter : 85 mm
Hole diameter for bolting : 20 mm
Disc thickness : 33 mm
Caliper pad thickness: 12 mm
Co-efficient of Friction **(μ)** : 0.5
Vehicle Curb Weight : 1140kg = 11180N
Axle weight distribution ratio (γ) : 0.3
Initial velocity : 80Km/hr = 22.22 m/s
Final velocity : 0 m/s
Percentage of kinetic energy absorbed by the disc : 0.9

Force Calculations

Vehicle load on the disc (FV) = (Total load of the vehicle) x (Axle weight ratio)
(FV) = 11180 x 0.3 = 3354 N
Area of contact (A) = (Area of segment from Outer radius) – (Area of segment from Inner radius)
A = 17463.931-1042.13 mm²
A = 16421.801 mm²
P_{max} = Force on the disc/ Area of the contact
P_{max} = (1.5 x 11180) / 16421.801
P_{max} = 1.02120 N/mm²
Normal load on the disc (F_N) = (P_{max}/2) x (Area of the brake pad)
F_N = (1.02120 / 2) x 16421.801
F_N = 8384.9715 N
Tangential Load (F_T) = Normal load x Coefficient of friction
F_T = 8384.9715 x 0.5
F_T = 4192.4857N
Total load on disc while braking (F_S) = $F_N + F_T + F_V$
F_S = 8384.9715 + 4192.4857 + 3354
F_S **= 15931.4572N**

Brake torque acting on the disc brake:

Brake torque on the disc = (Total load on the disc) x (Radius of the rotor disc)
= 15931.4572 x 0.195
= 3106.634N-m

Braking distance:

Distance covered by the vehicle during braking = X m
Work done during braking = Kinetic energy released during braking
$_{FS}$ x (X) = (mv²) / 2
15931.4572 x (X) = 1140 x (22.22) ² / 2
X = 17.66 m

8. SOLIDWORKS

Solid Works is mechanical design automation software that takes advantage of the familiar Microsoft Windows graphical user interface.

It is an easy-to-learn tool which makes it possible for mechanical designers to quickly sketch ideas, experiment with features and dimensions, and produce models and detailed drawings.

A Solid Works model consists of parts, assemblies, and drawings.

- Typically, we start with a sketch, make a base element, and after that add more highlights to the model. (One can likewise start with a insert surface or strong geometry).
- We are allowed to refine our plan by including, changing, or reordering highlights.
- Associative between parts, assemblies, and drawings that progressions made to one view are consequently made to every other view.
- We can create illustrations or congregations whenever in the design procedure.

SolidWorks mechanical design robotization programming is a component based, parametric strong demonstrating configuration instrument which preferred standpoint of the simple to learn windows TM graphical user interface. We can make completely relate 3-D strong models with or without while using programmed or client characterized relations to catch plan purpose.

Outline aim is the means by which the maker of the part needs it to react to changes and updates. For instance, you would need the gap at the highest point of a drink can to remain at the best surface, paying little respect to the stature or size of the can.

Several ways a part can be build like

Layer-cake approach: The layer-cake approach constructs the section one piece at a time, including each layer, or feature, onto the past one.

Potter's wheel approach:

The potter's wheel approach manufactures the part as a solitary rotated feature. As a solitary draw speaking to the cross area incorporates all the data and measurements important to influence the part as one to include.

Manufacturing approach:

In an assembly, the simple to draw relations is mates. Similarly as outline relations characterize conditions, for example, tangency, parallelism, and concentricity as for portray geometry, get together mates characterize identical relations as for the individual parts or segments, permitting the simple development of assemblies. SolidWorks likewise incorporates extra propelled mating highlights, for example, designed gear and cam supporter mates, which permit displayed, adapt congregations to precisely recreate the rotational development of a real apparatus prepare.

At long last, sketches can be made either from parts or congregations. Perspectives are naturally produced from the strong model, and notes, measurements and resistances would then be able to be effortlessly added to the illustration as required. The illustration module incorporates most paper sizes and norms.

A Solid Works display comprises of parts, assemblies, and drawings.

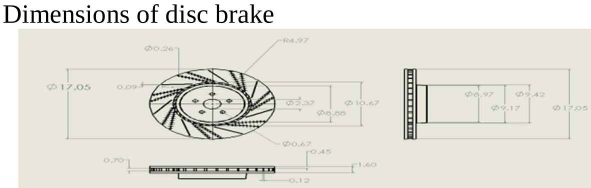
(1) Part: Individual segments are attracted the type of part illustrations.

(2) Assembly: The individual parts are collected in this district.

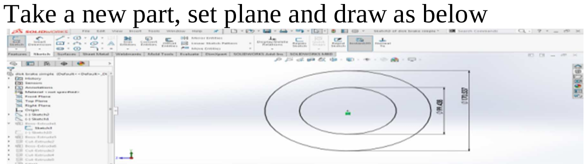
(3) Drawings: This contains definite data of the get together.

9. DESIGN OF DISK BRAKE

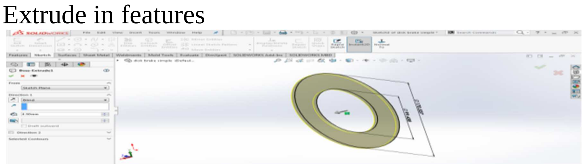
Dimensions of disc brake



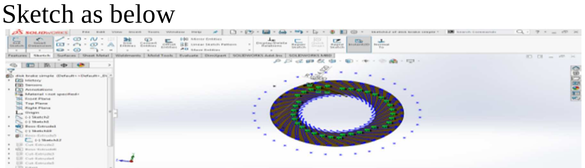
Take a new part, set plane and draw as below



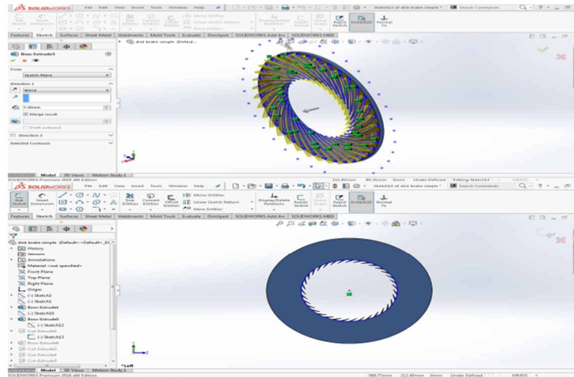
Extrude in features



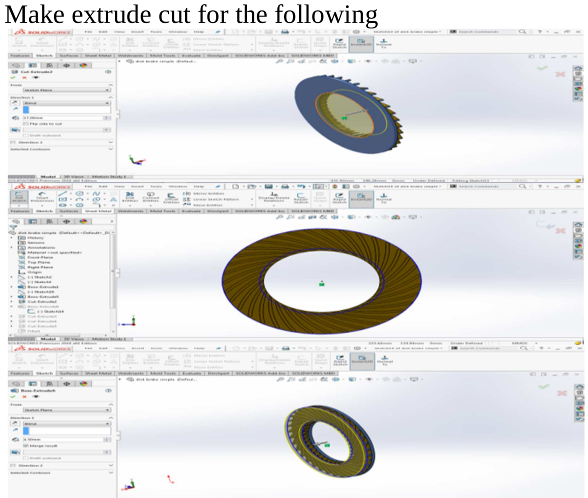
Sketch as below



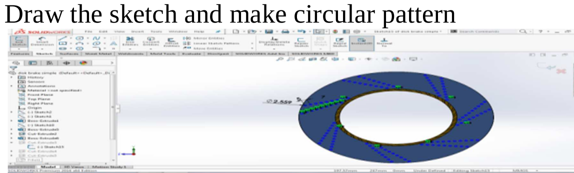
Extrude it



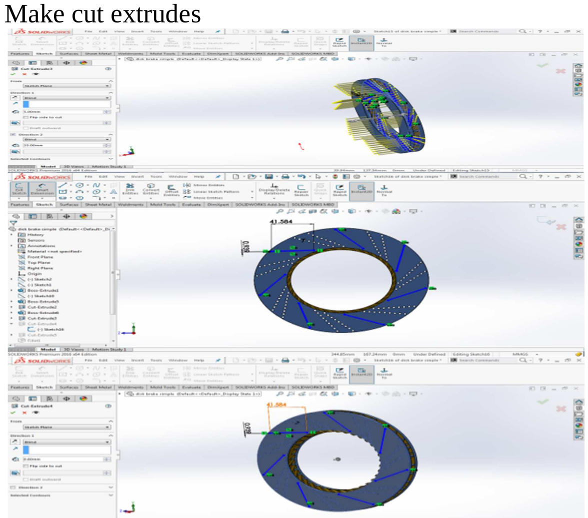
Make extrude cut for the following

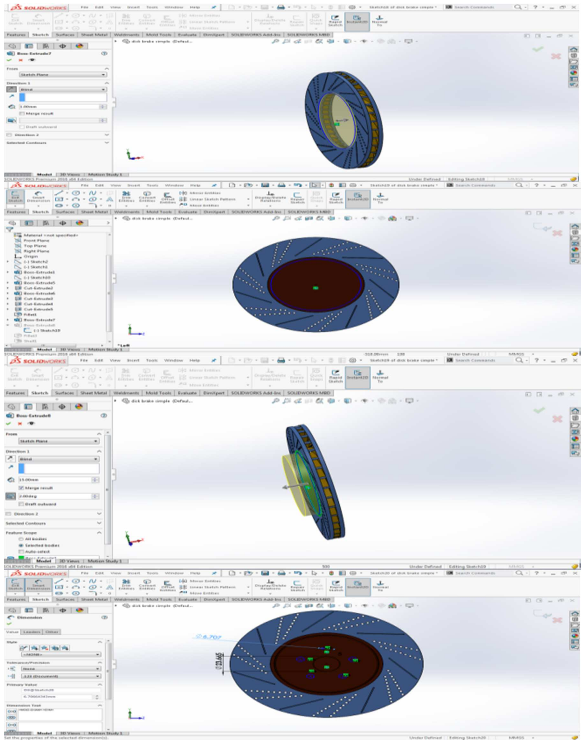


Draw the sketch and make circular pattern

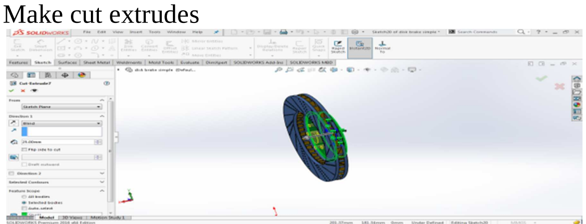


Make cut extrudes

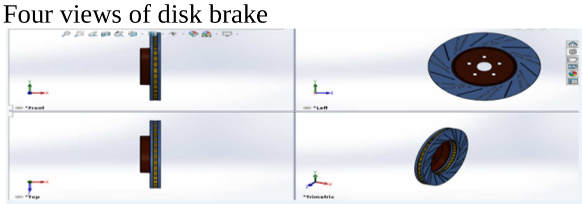




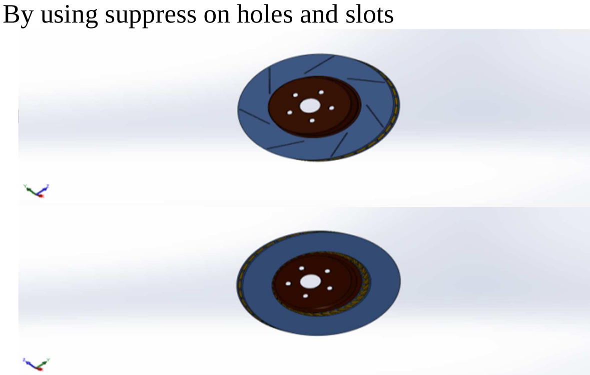
Make cut extrudes

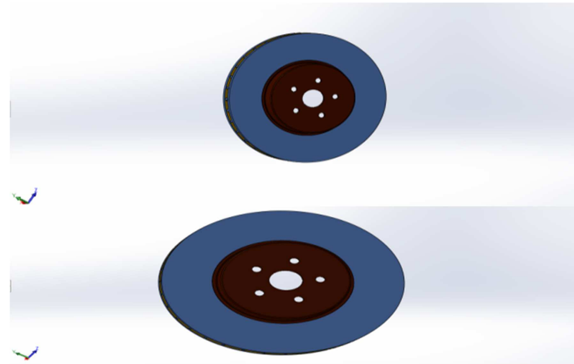


Four views of disk brake



By using suppress on holes and slots





Final design of Disc brake

10. INTRODUCTION TO SIMULATION

Solid Works Simulation is a plan investigation framework completely coordinated with Solid Works. Strong Works Simulation gives recreation answers for straight and nonlinear static, recurrence, clasping, warm, weariness, weight vessel, drop test, direct and nonlinear dynamic and streamlining examinations. Powered by quick and exact solvers, Solid Works Simulation empowers you to tackle huge issues instinctively while you plan. Solid Works Simulation comes in two packs: Solid Works Simulation Professional and Solid Works Simulation Premium to fulfill your investigation needs. Solid Works Simulation abbreviates time to showcase by sparing time and exertion in hunting down the ideal plan.

Fig8: Simulation example

Benefits of Simulation:

Subsequent to building your model, you have to ensure that it performs effectively in the field. Without investigation devices, this assignment must be replied by performing costly and tedious item advancement cycles. An item advancement cycle regularly incorporates the accompanying advances:

1. Building your model.
2. Building a model of the outline.
3. Testing the model in the field.
4. Evaluating the consequences of the field tests.
5. Modifying the outline in light of the field test comes about.

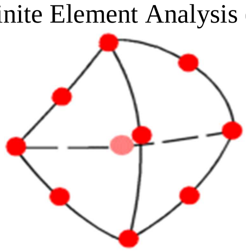
Basic Concepts of Analysis:

The product utilizes the Finite Element Method (FEM). FEM is a numerical system for examining building outlines. FEM is acknowledged as the standard investigation technique because of its all inclusive statement and reasonableness for PC execution. FEM partitions the model into numerous little bits of straightforward shapes called elements adequately supplanting a mind boggling issue by numerous basic issues that should be unraveled all the while.

Elements share regular focuses called nodes. The way toward isolating the model into little pieces is called meshing.

The conduct of every component is notable under all conceivable help and load situations. The limited component technique utilizes elements with various shapes.

The reaction anytime in an element is interjected from the reaction at the element nodes. Every node is completely depicted by various parameters relying upon the investigation compose and the element utilized. For instance, the temperature of a node completely depicts its reaction in warm examination. For auxiliary examinations, the reaction of a node is depicted, when all is said in done, by three interpretations and three pivots. These are called degrees of flexibility (DOFs). Examination utilizing FEM is called Finite Element Analysis (FEA).



A tetrahedral element. Red dots represent nodes. Edges of an element can be curved or straight.

The software details the conditions administering the conduct of every element contemplating its availability to different elements. These conditions relate the reaction to known material properties, restraints, and loads.

Analysis Steps:

The steps needed to perform an analysis depend on the study type. You complete a study by performing the following steps:

- Create an investigation characterizing its examination write and options.
- If required, characterize parameters of your investigation. A parameter can be a model measurement, material property, force value, or any other input.
- Define material properties.
- Specify restrictions and burdens.
- The program naturally makes a mixed work when diverse geometries (solid, shell, auxiliary individuals and so on.) exist in the model.
- Define part contact and contact sets.
- Mesh the model to separate the model into numerous little pieces called elements. Fatigue and optimization thinks about utilize the lattices in referenced examinations.
- Run the examination.

11. SPECIFIC CAPABILITIES OF SOLID WORKS SIMULATION:

1. Static Analysis:

At the point when loads are connected to a body, the body twists and the impact of burdens is transmitted all through the body. The outside loads incite inward loads and responses to render the body into a condition of balance. Linear Static examination displacements, strains, stresses, and response forces under the impact of connected loads.

2. Thermal Stress Analysis:

Changes in temperature can actuate considerable misshapenness, strains, and stresses. Thermal stress examination alludes to static analysis that incorporates the impact of temperature.

Perform thermal stress examination utilizing one of the accompanying choices:

• Using a uniform ascent or drop in temperature for the entire model.
• Using a temperature profile coming about because of a consistent state or thermal analysis.
• Using a temperature profile from Flow Simulation.

3. Frequency analysis :

On the off chance that the plan is subjected to dynamic situations, static examinations can't be utilized to assess the reaction. Recurrence studies can enable you to stay away from reverberation and plan vibration confinement frameworks. They additionally frame the reason for assessing the reaction of straight powerful frameworks where the reaction of a framework to a dynamic domain is thought to be equivalent to the summation of the commitments of the modes considered in the investigation.

4. Dynamic Analysis:

Dynamic investigation includes:

- Design auxiliary and mechanical frameworks to perform without disappointment dynamic environment.
- Modify framework's qualities (i.e., geometry, damping systems, material properties, and so forth.) to lessen vibration impacts.

5. Buckling analysis :

Used to calculate the clasping loads and decide the clasping mode shape. Both linear (Eigen esteem) and nonlinear buckling investigations are conceivable.

6. Non-linear static analysis:

Every single genuine structure carryon non-linearly somehow at some level of stacking. At times, straight investigation might be sufficient. In numerous different cases, the straight arrangement can deliver incorrect outcomes in light of the fact that the presumptions whereupon it is based are abused. Non linearity can be caused by the material conduct, extensive removals, and contact conditions. We can utilize a nonlinear report to take care of a direct issue. The outcomes can be marginally extraordinary because of various procedures. In the nonlinear static investigation, dynamic impacts like inertial and damping powers are not considered.

6. Drop test studies :

Drop test examines assess the impact of the effect of a section or assembly with an inflexible or adaptable planar surface. Dropping a protest on the floor is a commonplace application and henceforth the name. The program figures effect and gravity stacks naturally. No different load or limitations are permitted.

7. Fatigue Analysis :

Weakness is the prime reason for the disappointment of numerous items, particularly those made of metals. Cases of disappointment because of weariness incorporate, pivoting hardware, jolts, plane wings, customer items, seaward stages, ships, vehicle axles, bridges, and bones.

8. Pressure vessel Design study :

In a Pressure Vessel Design study, you combine the results of static studies with the desired factors. Each static study has a different set of loads that produce corresponding results. These loads can be dead loads, live loads (approximated by static loads), thermal loads, seismic loads, and so on. The Pressure Vessel Design study combines the results of the static studies algebraically using a linear combination or the square root of the sum of the squares (SRSS).

12. INTRODUCTION TO ANSYS

ANSYS 16.0 conveys creative, emotional reproduction innovation progresses in each, real physics teach, alongside changes in figuring pace and upgrades to empowering advances, for example, geometry taking care of, cross section and post-preparing. These progressions alone speak to a noteworthy advance ahead on the way ahead in Simulation Driven Product Development. Yet, ANSYS has come to considerably facilitate by conveying this innovation in an inventive reenactment structure, ANSYS Workbench 16.0.

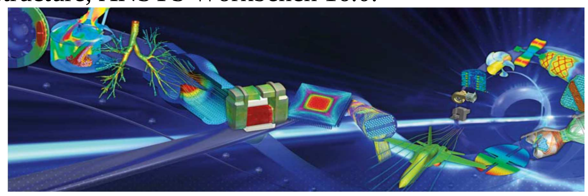


Fig.9: Ansys simulation

In ANSYS 16.0, while the inside applications may have all the earmarks of being conspicuous, they are bound together through the inventive assignment page that exhibits the possibility of the endeavor. This builds up the endeavor page thought.

Analysis Types:

The different type of analysis that can be performed in ANSYS

1. Structural static analysis:
2. Structural dynamic analysis
3. Structural buckling analysis
   - Linear buckling
   - Non linear buckling
4. Structural non linearity
5. Static and dynamic kinematics analysis
6. Thermal analysis
7. Electromagnetic field analysis
8. Electric field analysis
9. Fluid flow analysis
   - Computational fluid dynamics
   - Pipe flow
10. Coupled-field analysis

Advantages of ANSYS:

1. The ANSYS program is an adaptable and practical device which helps in the diminishment of modify on model.
2. ANSYS program is a graphical UI that encourages the clients with simple and instinctive way to program orders, documentation and capacities.
3. Keeping in mind the end goal to diminish the creation costs, ANSYS empowers to improve the plan in the advancement procedure itself.
4. ANSYS program helps in outlining the PC models and concentrate the physical reactions, for example, feelings of anxiety, temperature appropriation.

Steps in Solving:

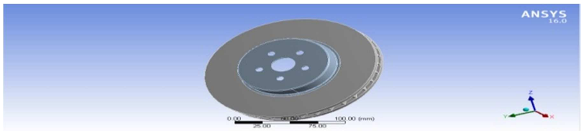
To solve ANSYS problem analytically, we need to define:

1. Solution domain
2. Physical model
3. Boundary condition
4. Physical properties

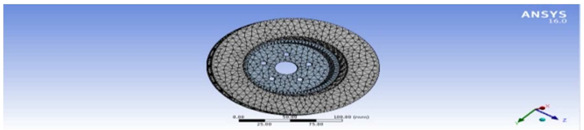
13. ANALYSIS ON DISC BRAKE

Static structural analysis on disc brakes :

Model

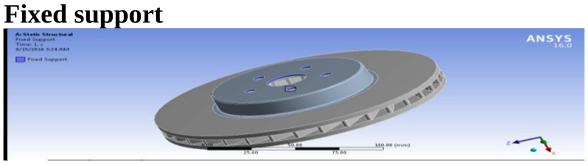


Mesh

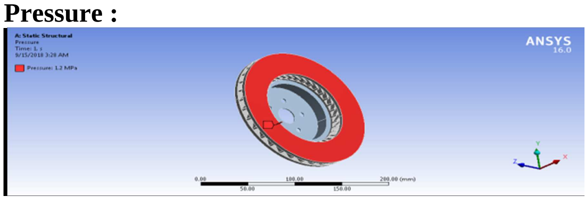


Nodes : 47067
Elements : 24833 are generated

Fixed support

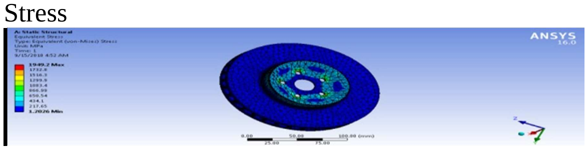


Pressure :

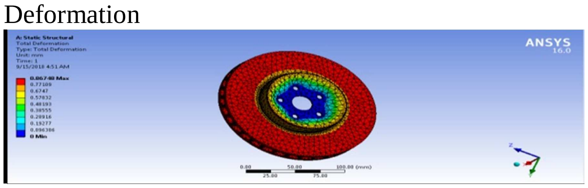


Material: Grey Cast Iron:

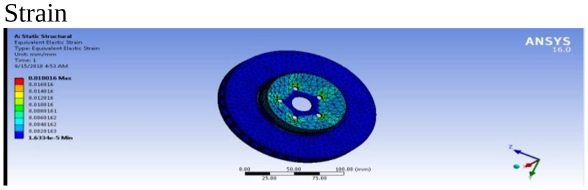
Stress



Deformation

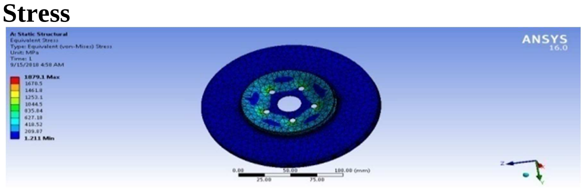


Strain

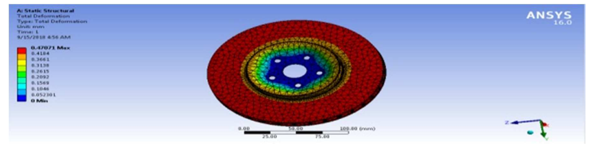


Material: Structural Steel

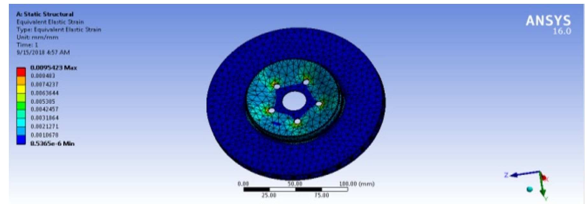
Stress



Deformation

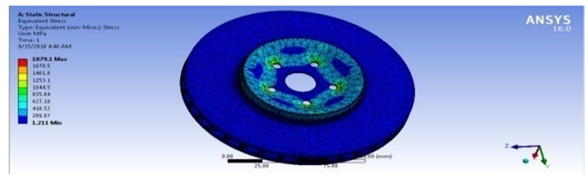


Strain

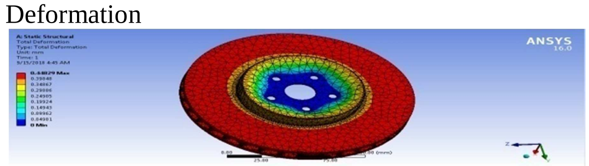


Material: Carbon Steel :

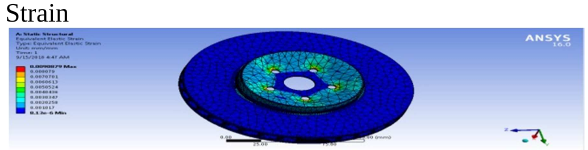
Stress



Deformation

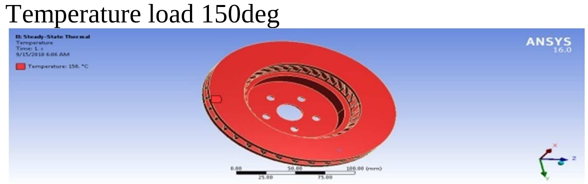


Strain

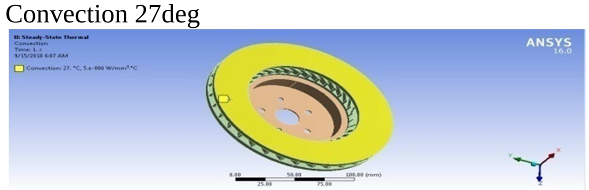


THERMAL ANALYSIS

Temperature load 150deg

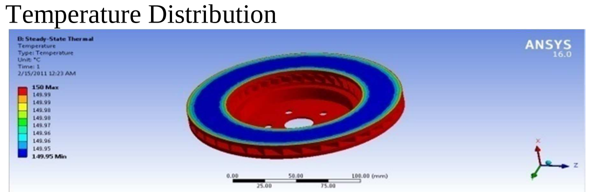


Convection 27deg

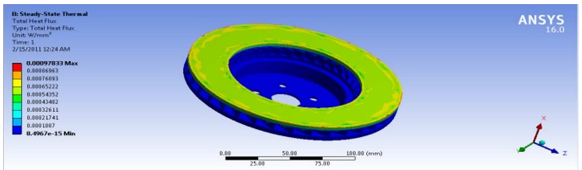


Material: Grey Cast Iron:

Temperature Distribution

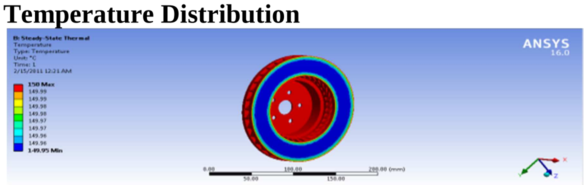


Total Heat Flux

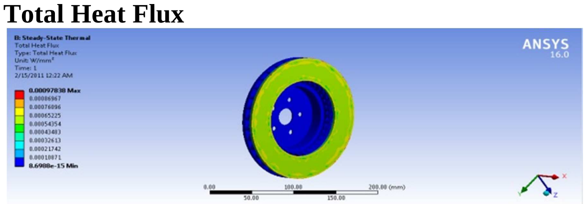


Material: Structural Steel

Temperature Distribution

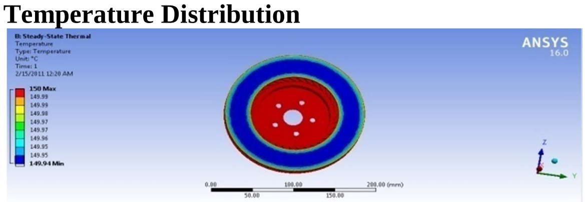


Total Heat Flux

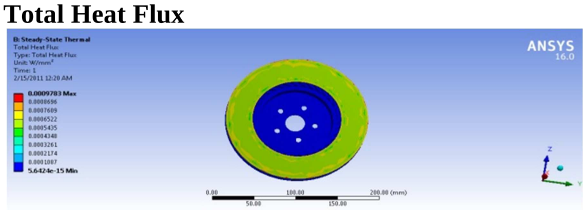


Material: Carbon Steel

Temperature Distribution



Total Heat Flux



14. RESULTS:

Static structural analysis results

Material	Stress (MPa)	Total deformation	Strain
Grey cast iron	1949.2	0.86748	0.018016
Structural Steel	1879.1	0.47071	0.0095423
Carbon steel	1879.1	0.44829	0.0090879

Steady state thermal analysis results

Material	Temperature distribution		Total heat flux
	max	min	
Grey cast iron	150	149.95	0.00097833
Structural Steel	150	149.95	0.00097838
Carbon steel	150	149.94	0.0009783

15. CONCLUSION:

- Modeling and analysis of the disc brake is done
- Modeling of disc brake is done using solid works design software.
- Structural and thermal analysis is done on disc brake using ansys work bench
- The structural analysis is done on disc brake by assigning various materials such as the grey cast iron, structural steel and carbon steel at certain pressure load
- Then thermal analysis is done by assigning above mentioned material at certain temperature and thermal distribution at applied temperature is studied.
- The material which is structurally stable and thermally showing huge temperature distributions is the most preferable material
- From the analysis we can conclude that structural steel got low stress but high deformation and strain values. Hence the carbon steel material is showing low stress, low deformations and maximum temperature distribution as the remaining materials.
- Thus the carbon steel material is the most preferable material

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