# Analytical Comparision of disc brakes with linear and curved shaped slots between plates for Structural Analysis on different parameter using through CATIA V5 R20 and ANSYS 15.0.7

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**Abstract- The process which converts the kinetic energy of the vehicle into mechanical energy is known as Braking, which must be dissipated in the form of heat. The device using for decelerating or stopping the rotation of a wheel is called as disc brake. A brake disc (or rotor) usually made of linear shaped slots between plates and a disc brake ( or rotor) usually made of curved shaped slots between plates having materials used in both is Structural Steel, is connected to the wheel and/or the axle. Friction material in the form of brake pads (mounted on a device called a brake calliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc to stop the wheel. The present thesis topic is generally deals with the improved analysis on Structural Analysis on two different models one have linear slots and other have curved slots between the two plates of disc brakes, using of solid and ventilated disc brake using CATIA v5 R20 and ANSYS15.0.7. In this research Coupled Analysis (of both different shaped slots) is performed in order to find the strength of the disc brake. In structural analysis displacement, ultimate stress limit for the design is found as an important factor.**

**Keywords — Modelling, Disc Brake, Ansys, Structural Analysis and as well as Thermal Analysis.**

**FORMULATION USED:**

**STEP-1**

$$\text{Let Speed of Vehicle (V)} = 62\,\frac{\text{Km}}{\text{hr}}$$

(random measurement)

$$\text{Mass of vehicle(m)} = 1000\text{Kg}$$

Kinetic Energy generated by vehicle

$$= \text{Total Heat Generated} = Q = \frac{1}{2}\text{mV}^2$$

$$= \frac{1}{2} * 1000 * 62^2 = 1922 \text{ Joule}$$

**STEP-2**

$$\text{Now Energy} = \text{Forec} * \text{Displacement}$$

$$1922 = \text{Force (F)} * 50\text{(Assume)}$$

Where 50 = spring displacement

(Let a random value)

$$\Rightarrow \text{Force (F)} = 38440\text{N}$$

**STEP-3**

$$\text{Now Pressure (P)} = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{38440}{0.000986}$$

$$= 3898501\,\frac{\text{N}}{\text{m}^2}$$

And hence therefore Pressure on each Pad

$$= \text{P}/2$$

$$= \frac{3898501}{2}$$

$$= 19492900\,\frac{\text{N}}{\text{m}^2} = 20 * 10^6\text{Pascal}$$

**STEP-4**

Area of rubbing faces = A

$$\text{therefore,} \quad A = 2\pi * ({r_0}^2 - {r_i}^2) * \theta * r$$

$$A = 0.000986\text{m}^2$$

***Units are taken in SI Unit.**

## I. INTRODUCTION

A brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine. In the process of performing this function, the brakes absorb either kinetic energy of the moving member or the potential energy given up by objects being lowered by hoists, elevators etc. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in to the surrounding atmosphere to stop the vehicle, so the brake system should have the following requirements:

**a.** The brakes must be strong enough to stop the vehicle with in a minimum Distance in an emergency.

**b.** The driver must have proper control over the vehicle during braking and the vehicle must not skid.

**c.** The brakes must have good ant fade characteristics i.e. their effectiveness should not decrease with constant prolonged application.

**d.** The brakes should have well anti wear properties.

Based on mode of operation brakes are classified as follows:

¬ Hydraulic brakes.

¬ Electric brakes.

¬ Mechanical brakes.

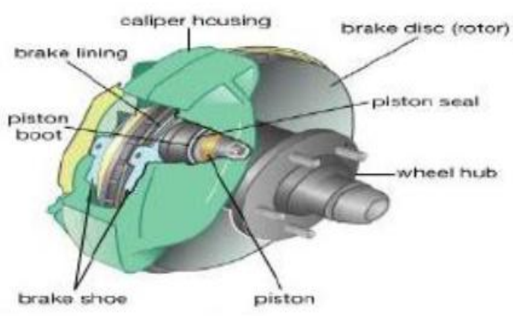


Fig 1 : Disc brakes

The mechanical brakes according to the direction of acting force may be sub divided into the following two groups:

**a.** Radial brakes.

**b.** Axial brakes.

**(a). Radial brakes:**

In these brakes the force acting on the brake drum is in radial direction. The radial brake may be subdivided into external brakes and internal brakes.

**(b). Axial brakes:**

In these brakes the force acting on the brake drum is only in the axial direction. e.g. Disc brakes, Cone brakes.

**(1) Disc brakes:**

A disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle, like the axle casing or the stub axle and is cast in two parts, each part containing a piston. In between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the caliper for the fluid to enter or leave each housing. These passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston. A schematic diagram is shown in the figure 1.

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. 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. 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.

Disc-style brakes development and use began in England in the 1890s. The first caliper-type automobile disc brake was patented by Frederick William Lanchester in his Birmingham, UK factory in 1902 and used successfully on Lanchester cars. Compared to drum brakes, disc brakes offer better stopping performance, because the disc is more readily cooled. As a consequence discs are less prone to the "brake fade"; and disc brakes recover more quickly from immersion (wet brakes are less effective). Most drum brake designs have at least one leading shoe, which gives a servo- effect. By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal or lever, this tends to give the driver better "feel" to avoid impending lockup. Drums are also prone to "bell mouthing", and trap worn lining material within the assembly, both causes of various braking problems.

## II. MODELING USING CATIA V5 R20

CATIA V5 R20 is the best in 3D product design, for feature industry-leading productivity tools that promote best practice in design while ensuring conformity with your industry and company standards. Integrated CATIA V5 R20 CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

## III. ANALYSIS USING ANSYS

Dr. John Swanson founded ANSYS. Inc in 1970 with a vision to commercialize the concept of computer simulated engineering, establishing himself as one of the pioneers of Finite Element Analysis (FEA). ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user- designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms.

MATERIAL DATA: STRUCTURAL STEEL

**TABLE-1**
**Structural Steel > Constants**

| | |
|---|---|
| Density | 7850 kg m^-3 |
| Coefficient of Thermal Expansion | 1.2e-005 C^-1 |
| Specific Heat | 434 J kg^-1 C^-1 |
| Thermal Conductivity | 60.5 W m^-1 C^-1 |
| Resistivity | 1.7e-007 ohm m |

**TABLE 2**
**Structural Steel > Compressive Ultimate Strength**

| Compressive Ultimate Strength Pa |
|---|
| 0 |

**TABLE 3**
**Structural Steel > Compressive Yield Strength**

| Compressive Yield Strength Pa |
|---|
| 2.5e+008 |

**TABLE 4**
**Structural Steel > Tensile Yield Strength**

| Tensile Yield Strength Pa |
|---|
| 2.5e+008 |

**TABLE 5**
**Structural Steel >Tensile Ultimate Strength**

| Tensile Ultimate Strength Pa |
|---|
| 4.6e+008 |

**TABLE 6**
**Structural Steel > Isotropic Secant Coefficient of Thermal Expansion**

| Reference Temperature C |
|---|
| 22 |

**TABLE 7**
**Structural Steel > Alternating Stress Mean Stress**

| Alternating Stress Pa | Cycles | Mean Stress Pa |
|---|---|---|
| 3.999e+009 | 10 | 0 |
| 2.827e+009 | 20 | 0 |
| 1.896e+009 | 50 | 0 |
| 1.413e+009 | 100 | 0 |
| 1.069e+009 | 200 | 0 |
| 4.41e+008 | 2000 | 0 |
| 2.62e+008 | 10000 | 0 |
| 2.14e+008 | 20000 | 0 |
| 1.38e+008 | 1.e+005 | 0 |
| 1.14e+008 | 2.e+005 | 0 |
| 8.62e+007 | 1.e+006 | 0 |

**TABLE 8**
**Structural Steel> Strain-Life Parameters**

| Strength Coefficient Pa | Strength Exponent | Ductility Coefficient | Ductility Exponent | Cyclic Strength Coefficient Pa | Cyclic Strain Hardening Exponent |
|---|---|---|---|---|---|
| 9.2e+008 | -0.106 | 0.213 | -0.47 | 1.e+009 | 0.2 |

**TABLE 9**
**Structural Steel > Isotropic Elasticity**

| Temperature C | Young's Modulus Pa | Poisson's Ratio | Bulk Modulus Pa | Shear Modulus Pa |
|---|---|---|---|---|
| | 2.e+011 | 0.3 | 1.6667e+011 | 7.6923e+010 |

**TABLE 10**
**Structural Steel > Isotropic Relative Permeability**

| Relative Permeability |
|---|
| 10000 |
| |

## IV. RESULT AND CONCLUSION:

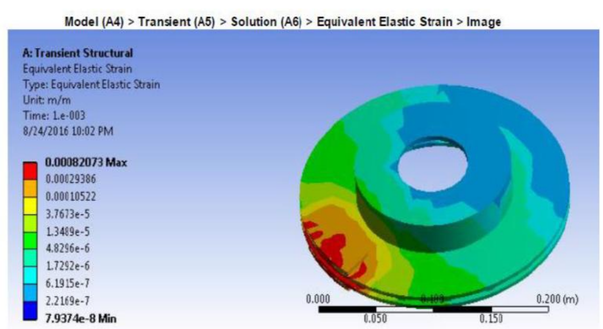


Fig-1: Equivalent Elastic Strain for linear slots

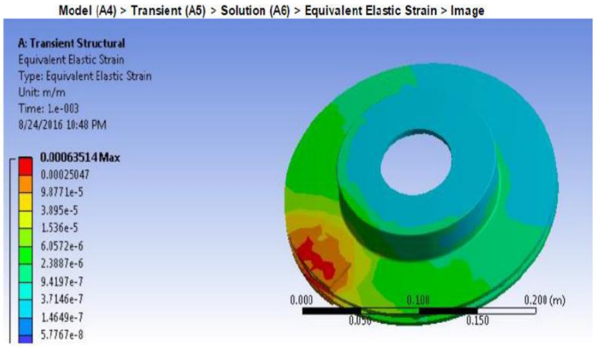


Fig-1’: Equivalent Elastic Strain for curve slots

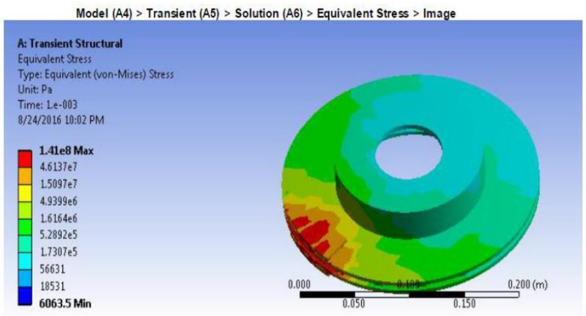


Fig-2: Equivalent Elastic Stress for linear slots

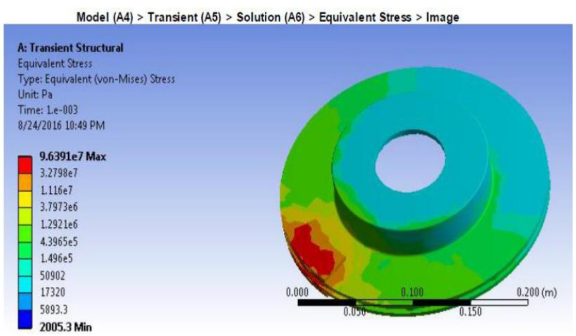


Figure-2’: Equivalent Elastic Stress for Curve Slots

## V. CONCLUSIONS:

The present paper (for Structural Analysis) study material may give a beneficial data for designing which is based on linear slots and curve slots between two rotating disc brakes and hence therefore improving the brake performance of disk brake system. From the observation we may find out that curve slots between the plates are more resistant capabilities rather than the linear slots between the plates, as figure-1 & figure-1’ ( comparision of Elastic Strain in both linear slots as well as curve slots), as figure-2 & figure-2’ (comparision of Elastic Stress in both linear slots as well as curve slots) on same parameters.

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