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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

Vivek Kumar*, Anshuka Srivastava
Sam Higgionbottom Institute of Agriculture, Technology & Sciences-Deemed University, Allahabad

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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 ventilated disc brake using CATIA v5 R20 and ANSYS15.0.7 we found that ventilated disc having curve slot have less development of strain and stress in comparision of ventilated disc having linear slot on same parameter. 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 as well as Thermal Analysis.

INTRODUCTION
CALCULATION FOR INPUT PARAMETERS
In the vehicle the rotor model heat flux is calculated for the vehicle moving with a velocity 17.22m/s (62kmph) and the following is the calculation procedure.
Data:

1. Mass of the vehicle = 1000Kg
2. Initial velocity (u) = 17.22m/s (62kmph)
3. Vehicle speed at the end of the braking application (v) = 0m/s
4. Brake rotor diameter = 0.262m
5. Axle weight distribution 30% on each side (γ) = 0.3
6. Percentage of Kinetic Energy that disc absorbs (90%) k = 0.9
7. Acceleration due to gravity g = 9.81m/s^2
8. Coefficient of friction fro dry pavement $\mu = 0.7$

Energy generated during braking;

$$K.E. = \frac{1}{2}\gamma.\frac{m(v-u)^2}{2} = 129465.3J$$

To calculate **stopping distance**

$$d = \frac{u^2}{2\mu g} = 21.59m$$

To calculate **deceleration time**

$$v = u + at, \qquad a = 6.87m/s^2$$

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$$Deceleration\ time\ = Braking\ time$$
$$= 2.51s$$

Braking Power: Braking power during continued braking is obtained by differentiating energy with respect to time $P_b = \frac{K.E.}{t} = 23366.25W$

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

PROPERTIES OF MATERIALS

Table- 1: Properties of Materials

Properties	Cast Iron	Carbon-Carbon Composite	Structural Steel
Density (Kg/m^3)	7100	1800	7750
Young's Modulus (GPa)	125	95	190
Poisson's ratio (1/m)	0.25	0.31	0.30
Thermal Conductivity (w/m-k)	54.5	40	26
Specific Heat (J/Kg-K)	586	755	500
Coefficient of Friction	0.2	0.3	0.2

INTRODUCTION

In today's growing automotive market the competition for better performance vehicle is growing enormously. The racing fans involved will surely know the importance of a good brake system not only for safety but also for staying competitive. The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc usually made of cast iron or ceramic composites includes carbon. Kevlar and silica, is connected to the wheel and the axle, to stop the wheel. A friction material in the form of the brake pads is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc.

This friction causes the disc and attached wheel to slow or stop. Generally, the methodologies like regenerative braking and friction braking system are used in vehicle. A friction brake generates frictional forces as two or more surfaces rub against each other, to reduce the movement. Based on the design configurations, vehicle friction brakes can be grouped into drum and disc brakes. If disc brakes are in solid body the heat transfer rate is low. Time taken for cooling the disc is low. If brake disc are in solid body, the area of contact between disc and pads are more. In disc brake system a ventilated disc is widely used in automobile braking system for improved cooling during braking in which the area of contact between disc and pads remain same. Brake assembly which is commonly used in vehicle as shown in figure-1.

A **disc brake** is a type of brake that uses calipers to squeeze pairs of pads against a disc in order to create friction that retards the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must be dispersed. Hydraulic disc brakes are the most commonly used form of brake for motor vehicles but the principles of a disc brake are applicable to almost any rotating shaft.

STRUCTURAL ANALYSIS COMPARISION BETWEEN LINEAR AND CURVE SLOTS

If applying the loads on brake, here are the selected Nodes and Elements and their comparision between linear and curve slots when using analysis 15.0.7.

Table-2: Geometrical comparision of slots structure between plates (Nodes/Element)

S.No.	Part-1	Part-2	Part-3
Linear slots NODES/ELEMENTS	287/32	6373/3043	287/32
Curve slots NODES/ELEMENTS	287/32	13903/7261	287/32

If applying the loads on brake, here are the selected minimum and maximum equivalent strain and equivalent stress their comparision between linear and curve slots when using analysis 15.0.7.

Table-3: Strength comparision of slots structure between plates (Strain/Stress)

S.No.	Equivalent Stress		Equivalent strain	
	Minimum	Maximum	Minimum	Maximum
Linear slots	210.44Pa	$8.5386*10^{6}$Pa	$1.9641*10^{-9}$	$4.9942*10^{-5}$
Curve slots	62.403Pa	$5.8751*10^{6}$Pa	$6.2048*10^{-10}$	$3.8706*10^{-5}$

As choosing the material of ventilated disc is structural steel, must follow the properties of material and during analysis we choose the following data;

Table-4: Structural Steel Constant

S.No.	*Properties*	*Value*
1	*Density*	*7850kg/m^{3}*
2	*Coefficient of thermal expansion*	*$1.2*10^{-5}$/C*
3	*Specific Heat*	*434J/KgC*
4	*Thermal Conductivity*	*60.5W/mC*
5	*Resistivity*	*$1.7*10^{-7}$ohm.m*
6	*Compressive ultimate Strength*	*0Pa*
7	*Compressive Yield Strength*	*$2.5*10^{8}$Pa*

RESULT AND CONCLUSION

COMPARISION ANALYSIS OF EQUIVALENT ELASTIC STRAIN BETWEEN LINEAR SLOTS AND CURVE SLOTS OF VENTILATED DISC (See Figure-2 & Figure-3)

During the braking time 2.51s, we analyze the equivalent elastic strain for linear slot having value of $4.9942*10^{-5}$m/m and equivalent elastic strain for curve slot having value of $3.8706*10^{-5}$m/m, from the figure-2 and figure-3.

During analysis we found that equivalent elastic strain for curve slot is much lesser than equivalent elastic strain for linear slot.

$$\textit{Equivalent Elastic Strain for linear slot}\ (\mathbf{4.9942\ x\ 10^{-5} m/m}) > \textit{Equivalent Elastic Strain for curve slot}\ (\mathbf{3.8706\ x\ 10^{-5} m/m})$$

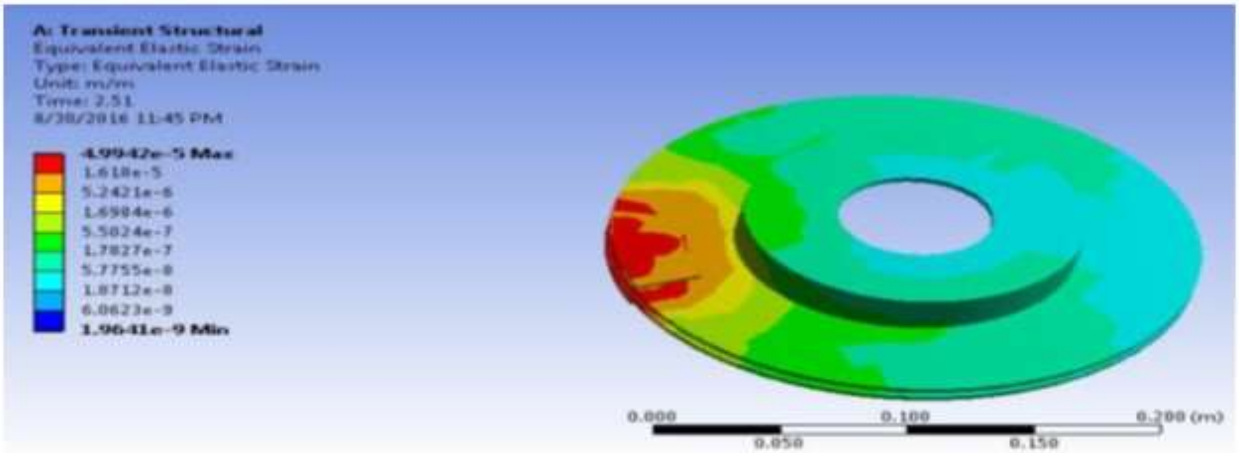

Figure-2: Equivalent Elastic Strain of a transient structural of linear lots of ventilated disc

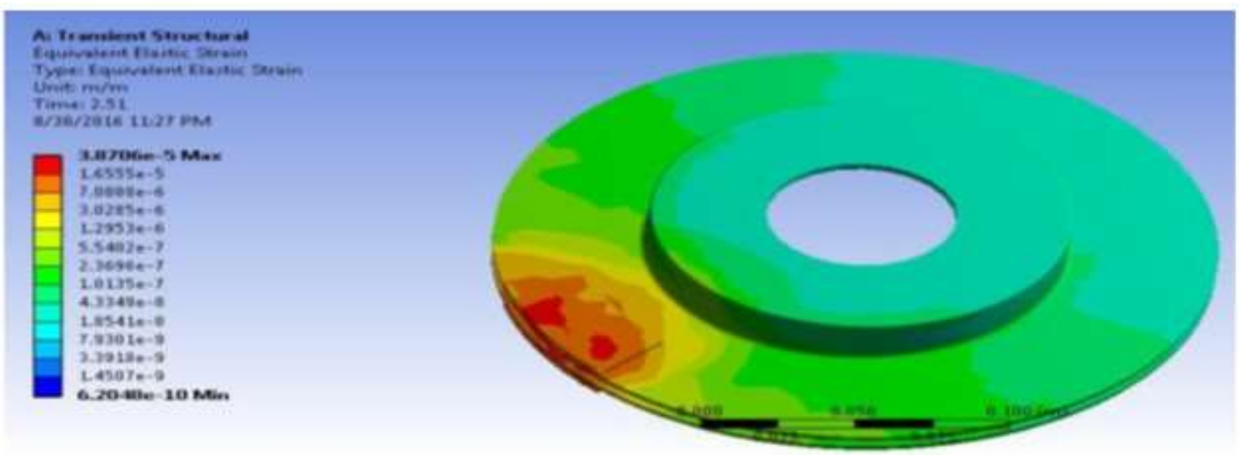

Figure-3: Equivalent Elastic Strain of a transient structural of curve slots of ventilated disc

RESULT AND CONCLUSION

COMPARISION ANALYSIS OF EQUIVALENT ELASTIC STRESS BETWEEN LINEAR SLOTS AND CURVE SLOTS OF VENTILATED DISC (See Figure-4 & Figure-5)

During the braking time 2.51s, we analyze the equivalent elastic stress (Von-Mises) for linear slot having value of 8.5386*10^6Pa and equivalent elastic stress (Von-Mises) for curve slot having value of 5.8751*10^6Pa, from the figure-4 and figure-5.

During analysis we found that equivalent elastic stress occurance for curve slot is much lesser than equivalent elastic strain occurance for linear slot.

$$\textit{Equivalent Elastic Stress for linear slot}\ (\mathbf{8.5386\ x\ 10^6 Pa}) > \textit{Equivalent Elastic Stress for curve slot}\ (\mathbf{5.8751 x\ 10^6 Pa})$$

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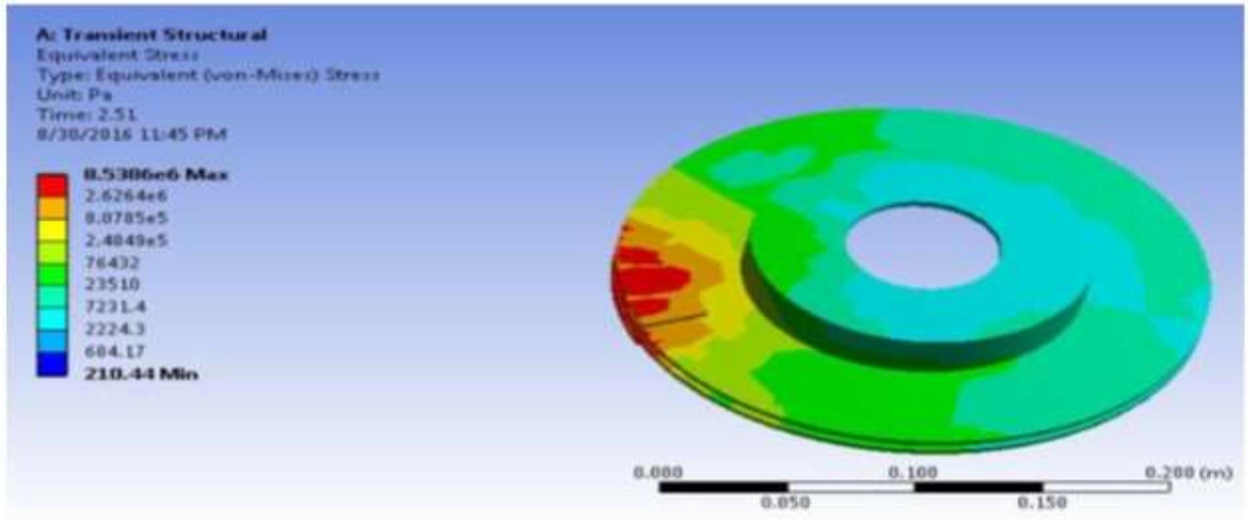

Figure-4: Equivalent Elastic Stress (Von-Mises) of a transient structural of linear lots of ventilated disc

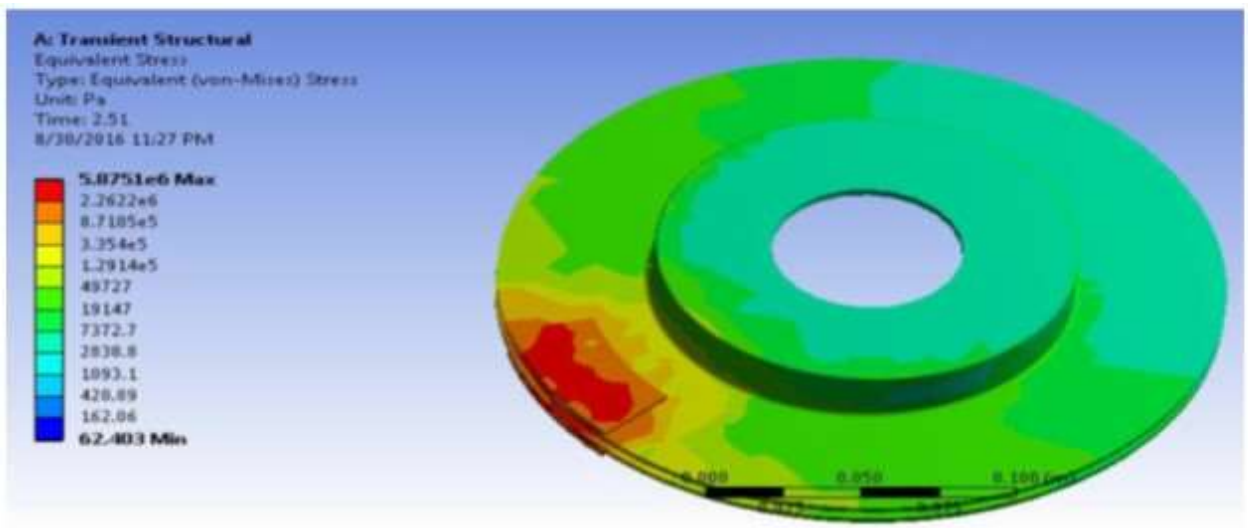

Figure-5: Equivalent Elastic Stress (Von-Mises) of a transient structural of curve slots of ventilated disc

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 ventilated 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-2 & figure-3 (comparision of Elastic Strain in both linear slots as well as curve slots), as figure-4 & figure-5 (comparision of Elastic Stress in both linear slots as well as curve slots) on same parameters.

$$Equivalent\ Elastic\ Strain\ for\ linear\ slot\ (\mathbf{4.9942\ x\ 10^{-5}m/m}) > Equivalent\ Elastic\ Strain\ for\ curve\ slot\ (\mathbf{3.8706\ x\ 10^{-5}m/m})$$

$$Equivalent\ Elastic\ Stress\ for\ linear\ slot\ (\mathbf{8.5386\ x\ 10^{6}Pa}) > Equivalent\ Elastic\ Stress\ for\ curve\ slot\ (\mathbf{5.8751x\ 10^{6}Pa})$$

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