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STRUCTURAL ANALYSIS OF FRICTION CLUTCH PLATE BY CHANGING FILLET RADIUS

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ABSTRACT

The clutch is one of the main components in automobiles. The engine power transmitted to the system through the clutch. The failure of such a critical component during service can stall the whole application. The driven mainplate failed normally during its operation due to cyclic loading. This project explains the structural analysis of the clutch plate by changing fillet radius. This project finds the maximum stress in failure region during operation. It also suggests design modifications to improve the life time of the clutch plate.

Key Words: Friction clutch plate, Fillet radius, ANSYS 12.0, CATIA V5.

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1. INTRODUCTION

A clutch is a mechanical device that engages and disengages the power, transmission, especially from driving shaft to drivenshaft. Clutches are used whenever the transmission of power or motion must be controlled either in amount or over time (e.g., electric screwdrivers limit how much torque is transmitted through use of a clutch; clutches control whether automobiles transmit engine power to the wheels).

In the simplest application, clutches connect and disconnect two rotating shafts (drive shafts or line shafts). In these devices, one shaft is typically attached to an engine or other power unit (the driving member) while the other shaft (the driven member) provides output power for work. While typically the motions involved are rotary, linear clutches are also possible.

In a torque-controlled drill, for instance, one shaft is driven by a motor and the other drives a drill chuck. The clutch connects the two shafts so they may be locked together and spin at the same

speed (engaged), locked together but spinning at different speeds (slipping), or unlocked and spinning at different speeds (disengaged).

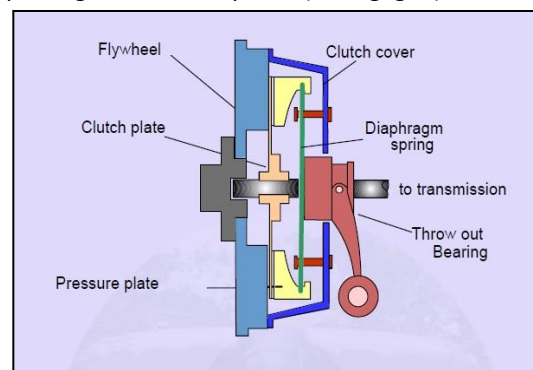


Figure 1: clutch plate with mountings.

1.1 Requirements of clutch

- Transmit maximum torque of the engine
- Engage gradually to avoid sudden jerks
- Dissipate maximum amount of heat
- Damp the vibrations and noise
- Dynamically balanced
- As small as possible
- Easy to operate

1.2 Clutch material

Table 1.1

Clutch components	Material
Cover plate	Mild steel
Damper spring retainer plate	
Cushion spring	
Clutch hub	
Diaphragm spring	
Retainer spring	
Damper spring	Spring steel
Coil spring	
Pressure plate	Cast iron
Bolts to fasten flywheel and cover plate	Steel
Clutch plate	Structural Steel
Rivets on cushion spring	Brass
Friction facing	Asbestos base
Rivets on facing	Aluminum brass

1.3 Clutch plate material properties

Table: 1.2

Properties	Sintered-iron	Gray Cast Iron	Structural Steel
Young's modules	275.79Mpa	120Gpa	200Gpa
Shear modules	53Gpa	44-45Gpa	76.9Gpa
Density	6200kg/m3	7200kg/m3	7850kg/m3
Passion ratio	0.34	0.29	0.3

2. THEORETICAL ANALYSIS ON DRIVEN PLATE

2.1 Design of a Disc or Plate Clutch

When the pressure is uniformly distributed over the entire area of the friction face then the intensity of pressure,

$$P = (W) / \pi [r_1^2 - r_2^2]$$

P=intensity of pressure,

(From the table or data book given for various materials i.e. 0.25 -0.4 Mpa for cast iron or steel)

P = Taking average 0.32 Mpa

W=Axial thrust

R_1 = Outer Radius (55mm)

R_2 = Inner Radius (16mm)

Therefore W = 2.7 kN

2.2 Max Pressure

Since the intensity of pressure is max at the inner radius (r_2) therefore

$$P_{\max}(r_2) = C \text{ (Constant)}$$

$$C = 16 P_{\max}$$

We also know that total force on the constant surface (W)

$$2.7 \text{ kN} = 2 \pi C [r_1^2 - r_2^2]$$

Note: $\{P=C/r\}$ Let P be the Normal Intensity of pressure at a distance "r" from the AXIS OF THE CLUTCH. Since the intensity of pressure varies inversely with the distance, therefore that is the reason why intensity of pressure is Maximum at inner radius (r_2) which causes propagation of crack.}

$$2.7 \text{ kN} = 2 \pi (16 P_{\max}) [55^2 - 16^2]$$

$$P_{\max} = 0.68 \text{ N/mm}^2$$

2.3 Min Pressure

Since the intensity of pressure is min at the outer radius (r_1), therefore

$$P_{\min}(r_1) = C \text{ (Constant)}$$

$$C = 55 P_{\min}$$

$$2.7 \text{ kN} = 2 \pi (55 P_{\min}) [55^2 - 16^2]$$

$$P_{\min} = 0.2 \text{ N/mm}^2$$

2.4 Average Pressure

$P_{\text{avg}} = \text{Total Normal Force} / \text{Area}$

$$P_{\text{avg}} = W / \pi [r_1^2 - r_2^2]$$

$$P_{\text{avg}} = 0.31 \text{ N/mm}^2$$

3. DESIGN OF CLUTCH PLATE IN CATIA V5 SOFTWARE

3.1 Model of Clutch Plate

Open CATIA V5 software, select X-Y plane and draw the 2D diagram of the clutch plate

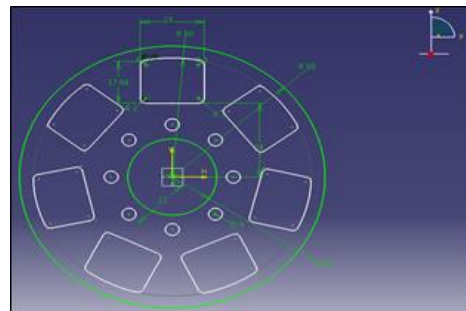


Figure 3.1 Dimensions of Clutch plate

Dimensions of the clutch plate

Outer diameter: 110mm

Inter Diameter: 32mm

Hole Diameter: 5mm
No of Holes: 6
Clutch plate thickness: 3mm
Rectangle dimensions: 23mm×17.66mm×3mm
Fillet radius: 0mm, 1.5mm, 2mm, 2.5mm, 3mm
Clutch plate material: Structural steel

3.2 DESIGN OF CLUTCH PLATE

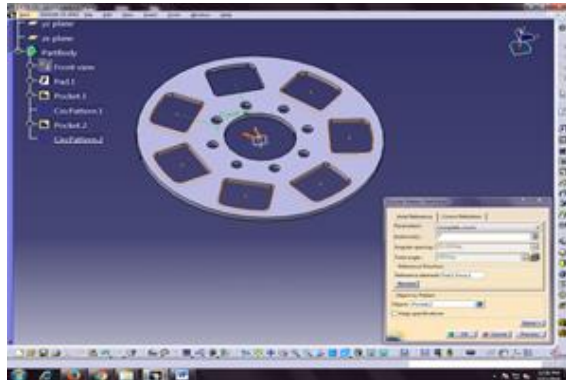


Figure 3.2 Solid Model of Clutch Plate

4. CLUTCH PLATE ANALYSIS USING ANSYS WORKBENCH

To analyzing this product the ansys work bench is required. So after design completed, the model is imported into the ansys work bench

The Material For Clutch (Structural Steel)

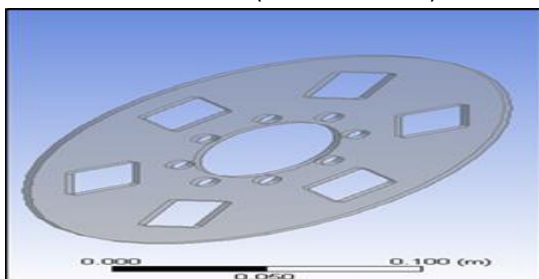


Figure 4.1: After importing

After importing the model into ansys work bent, meshing is required

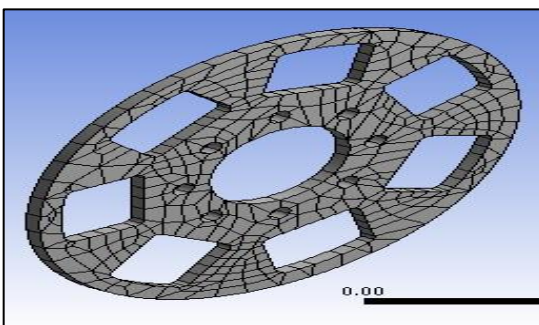


Figure 4.2 After meshing

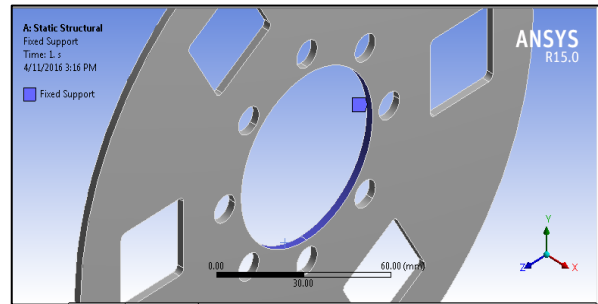


Figure 4.3 Fixed Support

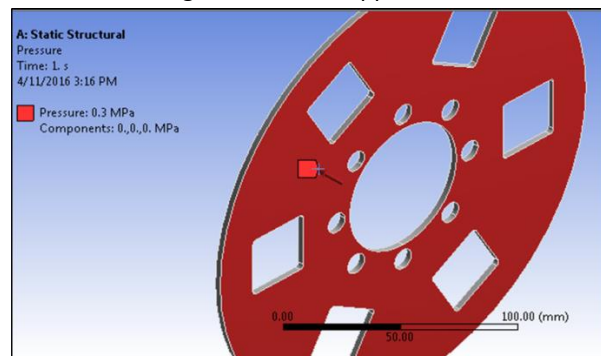


Figure 4.4: Pressure force

4.1 Without Fillet:

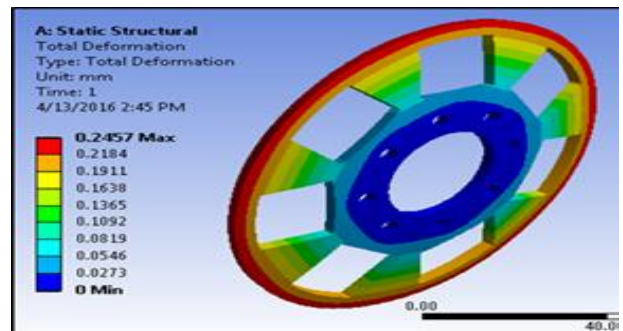


Figure 4.5: Total Deformation

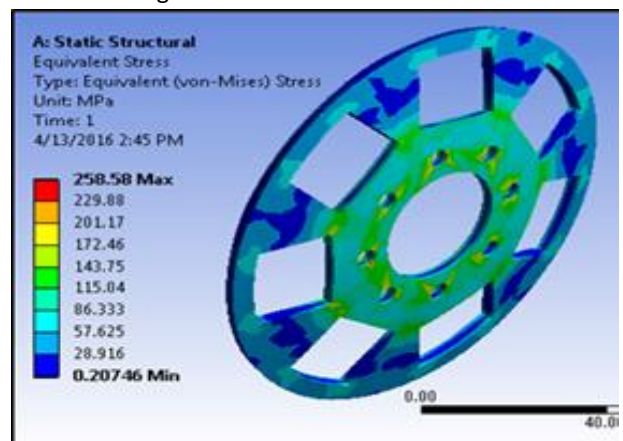


Figure 4.6: Equivalent Stress

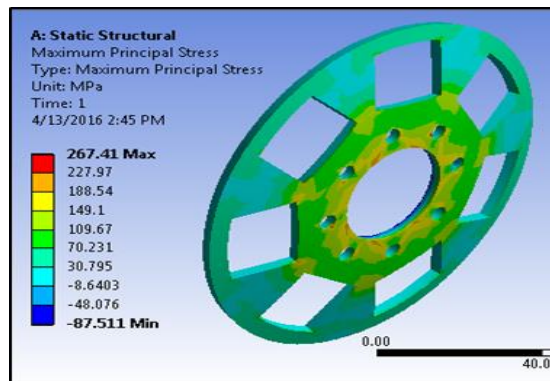


Figure4.7: Maximum Principal Stress

4.2 With 1.5mm Fillet

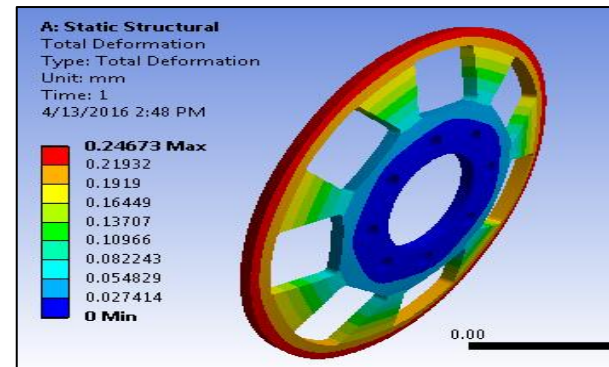


Figure 4.11: Total Deformation

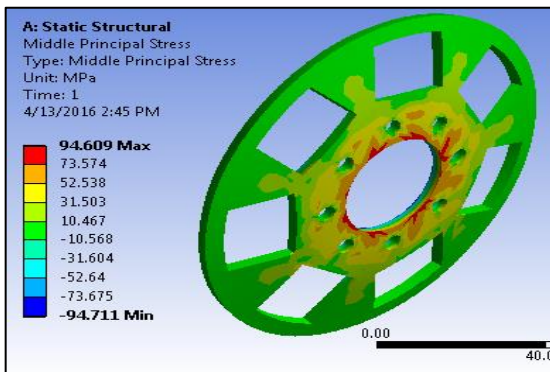


Figure4.8: Middle Principal Stress

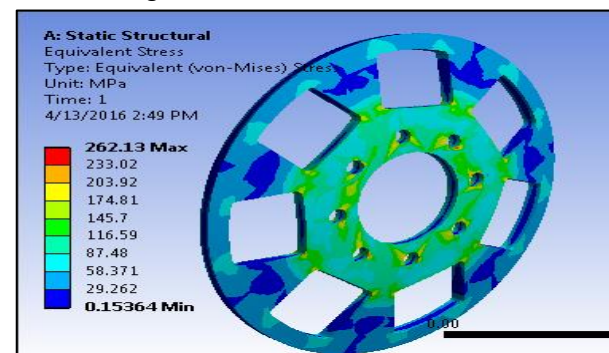


Figure 4.12: Equivalent Stress

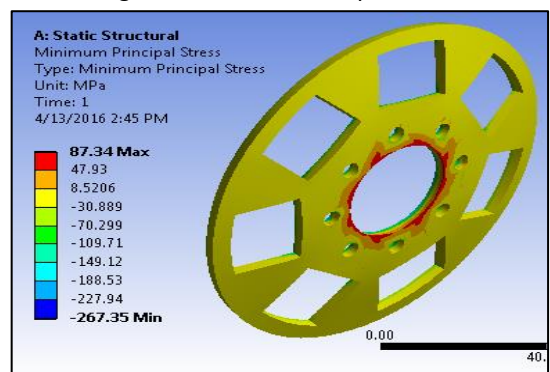


Figure 4.9: Minimum Principal Stress

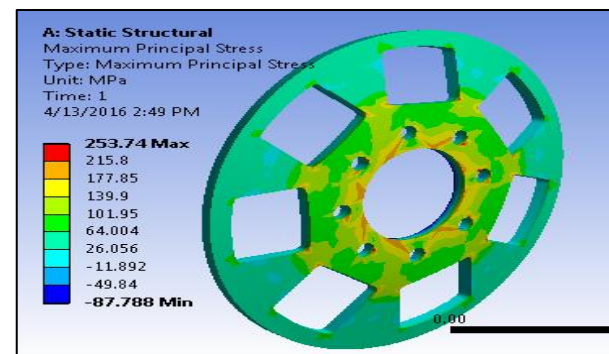


Figure4.13: Maximum Principal Stress

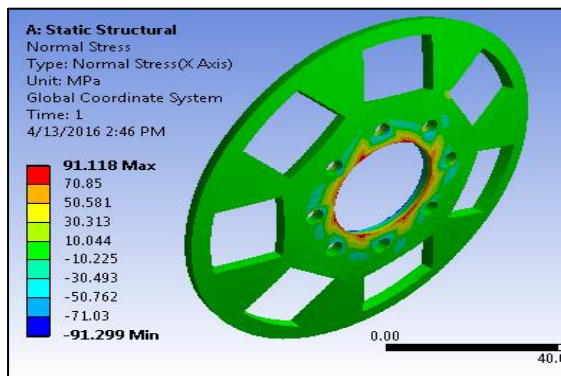


Figure4.10: Normal Stress

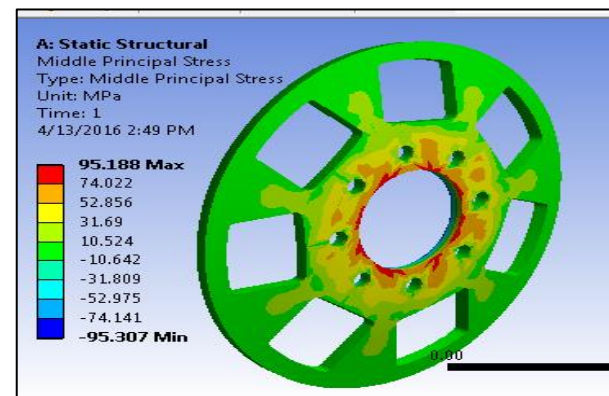


Figure4.14: Middle Principal Stress

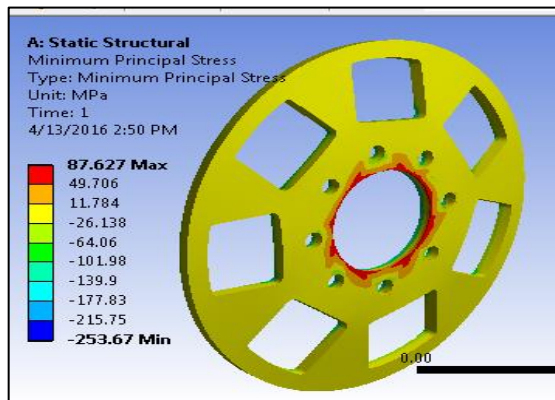


Figure 4.15: Minimum Principal Stress

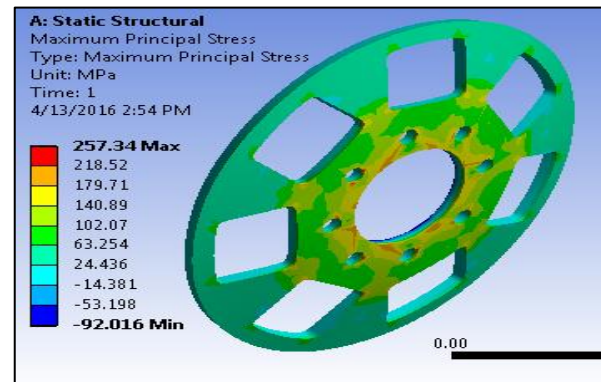


Figure4.19: Maximum Principal Stress

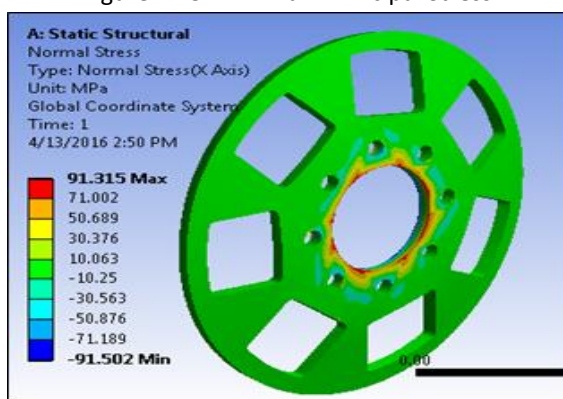


Figure 4.16: Normal Stress

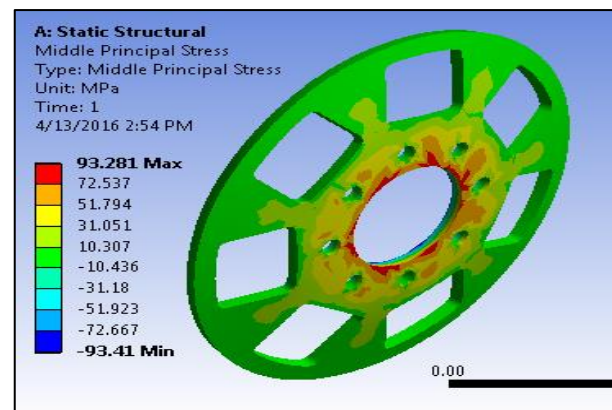


Figure 4.20: Middle Principal Stress

4.3 with 2mm fillet

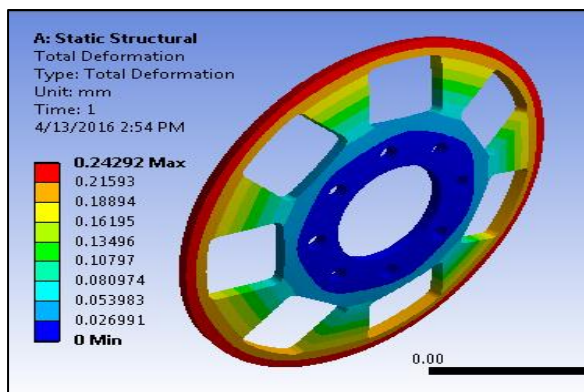


Figure 4.17: Total Deformation

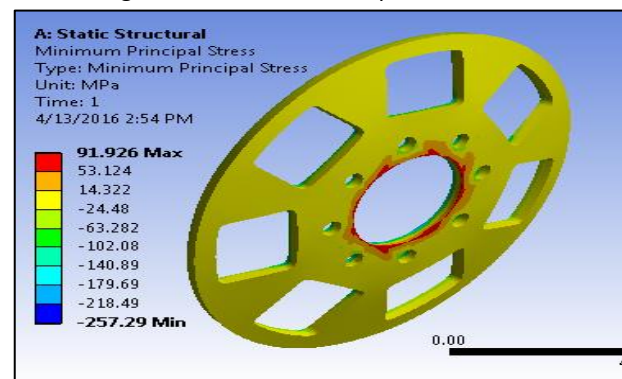


Figure4.21: Minimum Principal Stress

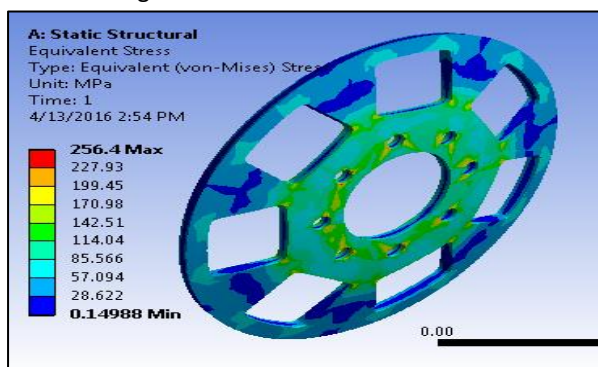


Figure 4.18: Equivalent Stress

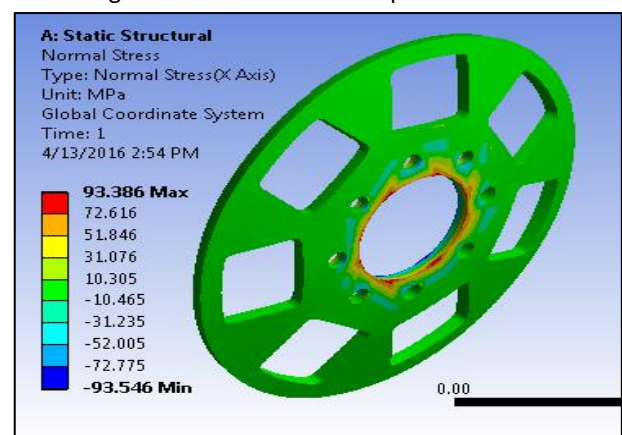


Figure4.22: Normal Stress

4.4 With 2.5mm fillet

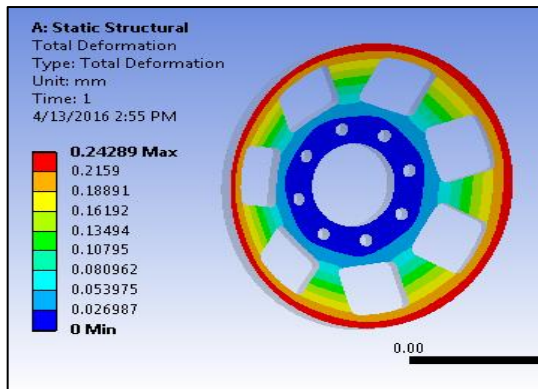


Figure4.23: Total Deformation

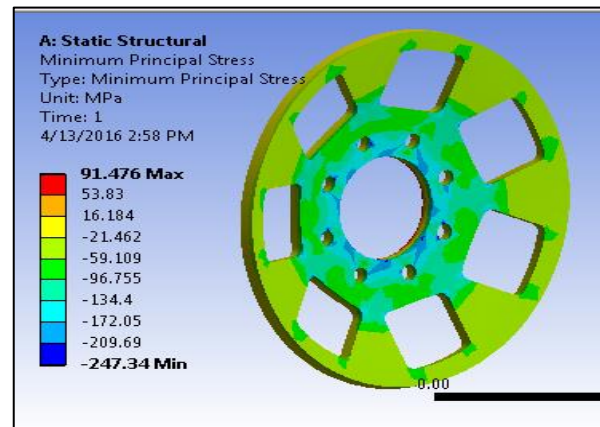


Figure4.27: Minimum Principal Stress

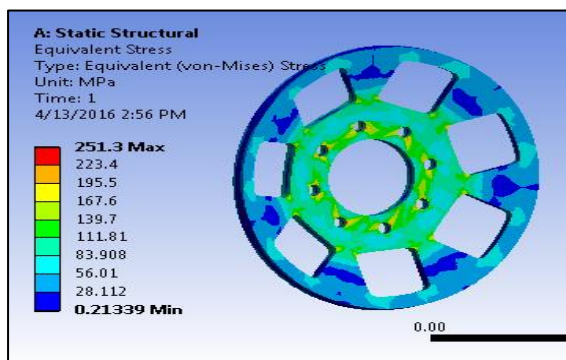


Figure4.24: Equivalent Stress

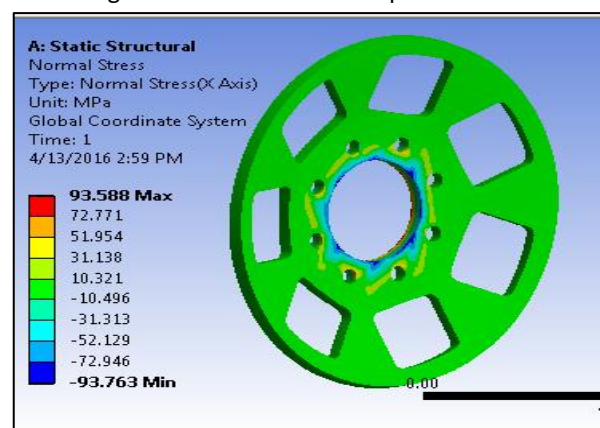


Figure4.28: Normal Stress

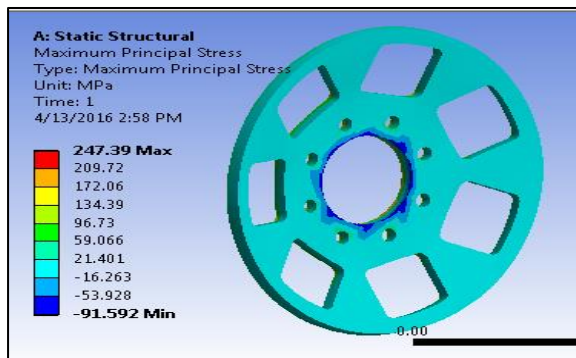


Figure4.25: Maximum Principal Stress

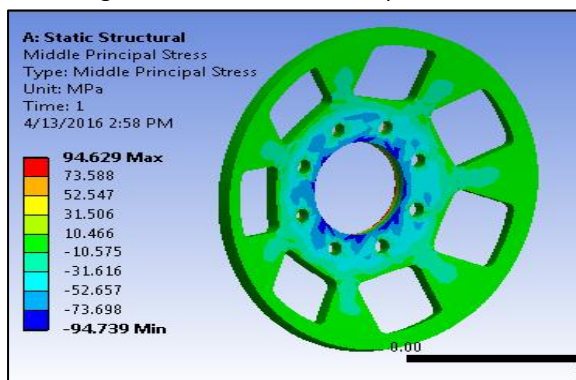


Figure4.26: Middle Principal Stress

4.5 with 3mm fillet

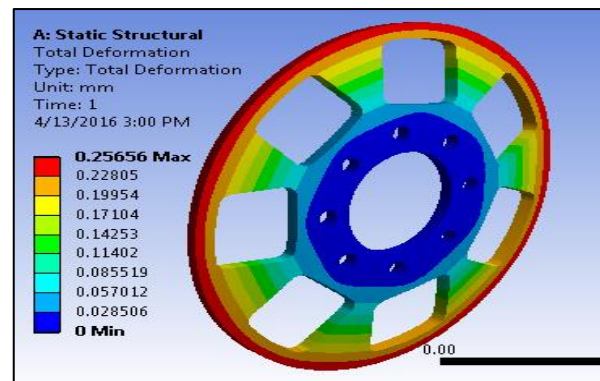


Figure 4.29: Total Deformation

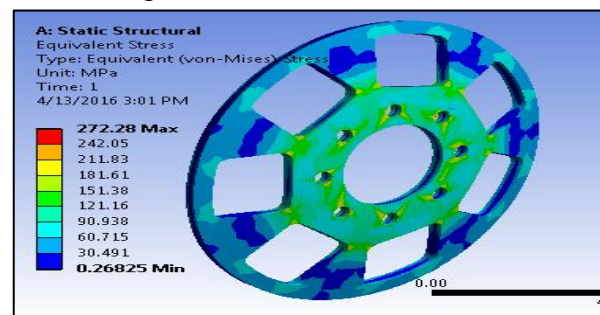


Figure 4.30: Equivalent Stress

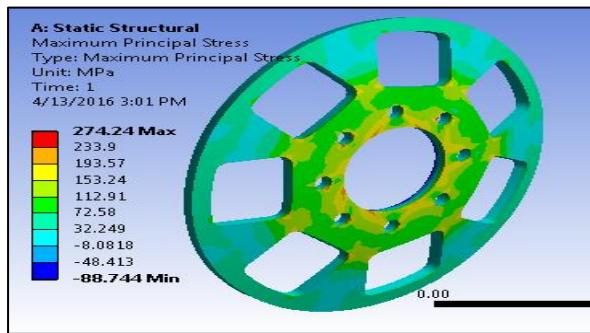


Figure 4.31: Maximum Principal Stresses

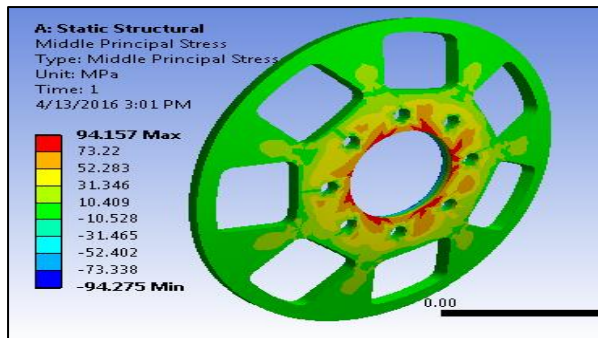


Figure 4.32: Middle Principal Stress

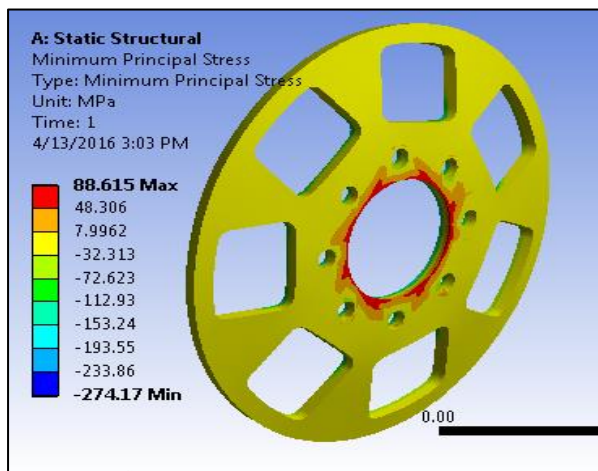


Figure 4.33: Minimum Principal Stress

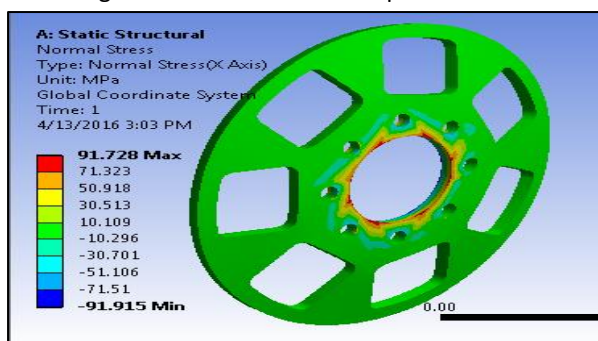


Figure 4.34: Normal Stress

5. Results

- We done the Static structural analysis on driven plate of clutch of structural steel

material with different fillet radius on Ansys work bench

- After done the analysis on clutch plate the following results are occurred

Fillet Radius	Total deformation	Equivalent stress	Normal stress
Without	0.2457	258.58	91.11
1.5mm	0.24673	262.13	91.315
2mm	0.24292	256.4	93.386
2.5mm	0.24289	251.3	93.588
3mm	0.25656	272.28	91.728

Fillet Radius	Max. Principle stress	Middle principle stress	Min. Principal stress
Without	267.41	94.609	87.34
1.5mm	253.74	95.188	87.627
2mm	257.34	93.281	91.926
2.5mm	247.39	94.629	91.476
3mm	274.24	94.157	88.615

6. Conclusion

- By reference of above table the stress and the deformation are slow down at the fillet radius of 2.5mm.
- The stress and deformation are without fillet respectively is 258.58mpa, 0.2457mm.
- The stress and deformation are 2.5mm fillet respectively is 251.3mpa, 0.24289mm.
- By compare with all the data the 2.5mm fillet clutch plate is better than all the clutch plates' models because the stress development and total deformation is low.
- Finally the 2.5mm fillet radius of driven plate is suitable for design of clutch and life of the clutch is increases.

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