International Journal of Scientific & Engineering Research Volume 11, Issue 6, June-2020
ISSN 2229-5518

Structural and Thermal Analysis of Drum Brake

[1]Venkatesh G, [2]Dr. Niranjan Hiremath[1]
M.tech Student,Machine Design Dept.REVA University,Bangalore [2]Associate Professor,School of Mechanical Engineering,REVA University,Bangalore

Abstract – A brake is a mechanical device which inhibits motion. A drum brake is a brake that uses friction caused by a set of shoes or pads that press against a rotating drum-shaped part called a brake drum. The commercial brake system uses disc brake for front wheels and drum brake for the rear wheels. Grey cast iron is the conventional material used for making brake drums of light and heavy motor vehicle. The brake drum is a critical component that experiences high temperatures and develop thermal stresses during application of brakes. In addition, the application of shoe pressure gives rise to mechanical loads. So the analysis takes into account both the thermal stresses and mechanical stresses together. So in this project we design the model of drum brake using Catia software and perform structural and thermal analysis using Ansys software and check how the temperature of the surface varies and also check what is the deformation and stress created in the model due to pressure applied by the brake shoes.

Index Terms— Brake Drum, Commercial Brake System, Conventional Material.Deformation.

---

1 Introduction

A brake is a device which slows down or stops the moving vehicle mostly by means of friction. Frictional brakes in automobiles stores heat while applying brakes and conducted into the air. Mostly drum brakes are used in trucks and rear wheels of cars. It is used mostly because of its low production cost. Drum brakes generally overheats, due to this it wear outs.

A. Foundation components

Foundation Components are basically the assembly components of the wheel. The mechanical components are controlled by brake drum. Drum brakes uses friction which is caused by pads or shoes that press outward against part called brake drum.

B. Backing plate

Backing plate is also called _Torque plate‘. It increases the rigidity of the whole setup and supports the housing. This also protects from foreign materials like dust. Back plate must be strong and wear resistant. Since all breaking operations exert pressure on backing plate.

C. Brake drum

Cast iron is usually used for making brake drum. When you apply brake, lining advances radially on the inner of the drum, which in return generates heat due to friction.

D. Wheel Cylinder

Brakes are operated by one wheel cylinder on the wheel. There are two pistons which operates the shoes. The shoes are leading shoe and trailing shoe.

E. Brake Shoe

They are basically made up of two pieces of steel welded together, Web is of crescent shaped and it has various shapes of slots for parking brake linkage, return springs, self adjusting components and hold down software.

F. Normal braking

During the application of brake, Brake fluid is flown into wheel cylinder from master cylinder, under pressure which thrusts the brake shoes comes to connection with inner surface of the drum.Due to this rotation of the brake drum will be reduced.

G. Automatic Self -adjustment

The shoes should travel a greater distance in order to reach the drum to reduce wear. At certain point, self-adjusting mechanism adjusts the rest position of the shoes, so that shoes comes closer to drum and adjusting lever rocks to advance gear by one tooth. Gear has threads like a bolt, it unscrews when it turns. Adjuster keeps shoes closer to drum.

H. Emergency/Parking brake

It controls brakes with an array of steel cables which are connected to either foot pedal or hand lever. Cable pulls lever which is main- tained in brake which in turn connects to brake shoe.

2 Literature Review

Vytenis Surblys [1] et.al explained that if the dependence of the braking force variation on the pedal is known, the value of the brak- ing force when the mass of the vehicle conforms to its maximum possible mass can be forecasted. The dependence of the braking force on the pedal pressure force growing is linear.

Abhishek Patel [2] et.al analysed titanium and aluminium alloy which is used for brake shoe lining and calculated for temperature and stress at maximum level, heat flux and deformation.

Anup Kumar [3] et.al predicted that design is safe and works properly at the given load condition for distributing temperature ac- curately.

Meenakshi Kushal [4] et.al made a comparative study between Controlled Expansion alloy and Al alloy brake drums based on weight, temperature rise and deformation. The Controlled Expansion alloys brake drum has comparatively less weight than Pure Alumini- um and Aluminium alloys brake drum. Controlled Expansion alloys have low expansion, stiffer, excellent machinability as compared to Pure Aluminium and Aluminium alloys, From the above observa- tions, she concluded that controlled expansion alloys are better than candidate material for drum of the automobiles.

P Venkataramana [5] et.al compared the brake drum of NANO car with INDICA. He tested the brake drum under various loading con- ditions, and results indicated that size of the brake drum is smaller in NANO than INDICA for given load conditions.

C. Bala Manikandan [6] et.al modified the traditional brake system into four shoe brake system, by this, Area of contact between brake lining and brake drum is increased. Increase in contact area lead to the reduction of braking time and braking distance will also get re- duced simultaneously. Reduction in braking time, improves the life of brake lining

NOUBY M. GHAZALY [7] et.al made a brake test rig for measur- ing drum brake performance at various environmental and operating conditions. Forces are applied considering dry and humid conditions and also considering the sliding speed of the automobile. Outcomes of the experiments showed increase in coefficient of friction between brake lining and the brake drum with increasing speed at wet and dry conditions.

Aravind P Jinturkar [8] et.al explained about weight reduction of brake drum along with the peripheral region and increase in stiffness of the brake drum.
Amit Phatak [9] et.al explained two parameters of natural frequencies which are stiffness and mass for reduction of drum brake squeal in automotive braking system.
D. Rambabu [10] et.al designed best brake drum considering stress, displacement and optimized weight. He also developed finite element model for assessing the behaviour of the drum reference to pressure, displacement and pressure parameters.
Ramesh [11] et.al developed analytical model with 4 Degree of Freedom and time domain analysis was performed. The analysis showed that even for a small deviation from the symmetric condition, there was a drastic change in the resultant reaction forces, which finally transmits to the chassis and leads to the source of vibro-acoustic.
Bako Sunday [12] et.al explained the way of refining the heat transfer dissipation of a vehicle's brake drum without a change in weight and without conceding the current properties and necessities of the vehicle's brake drum.

3. Design of Drum Brake

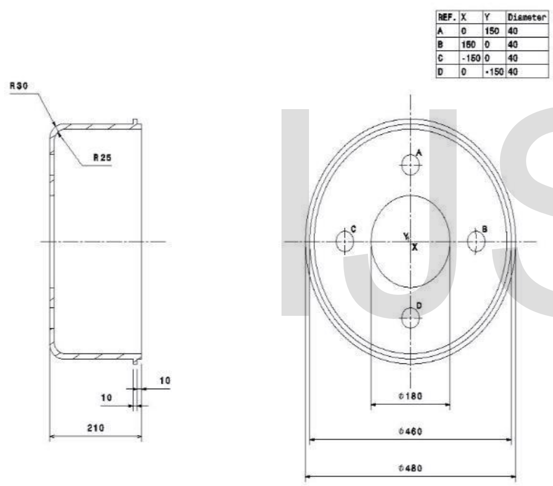


Fig 1: Dimensions of Brake Drum

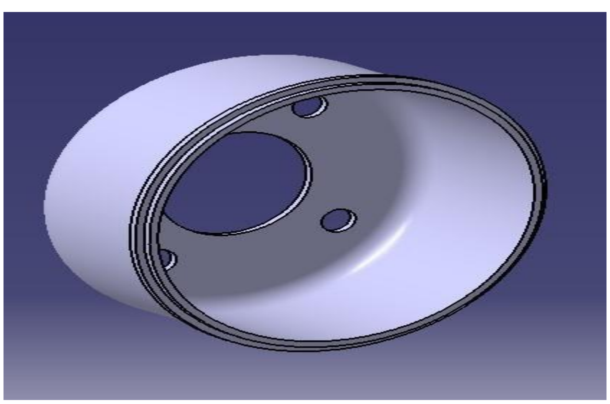


Fig 2: 3D view of brake Drum

Table1: Drum Brake Parameters

Parameters	Model
Outer Diameter (mm)	480
Inner Diameter (mm)	460
Center Hole Diameter (mm)	180
Circular pattern Hole Diameter(mm)	40
Height of the Drum (mm)	210

4. Boundary Conditions

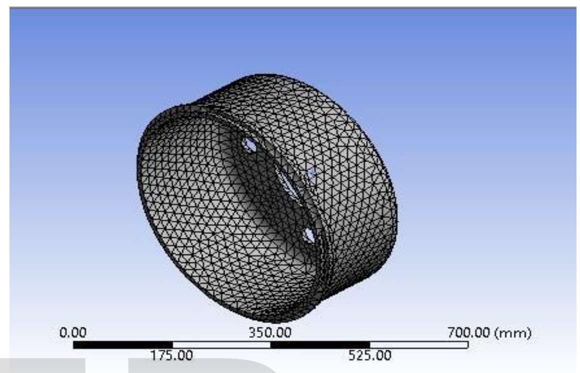


Fig 3: Normal Mesh

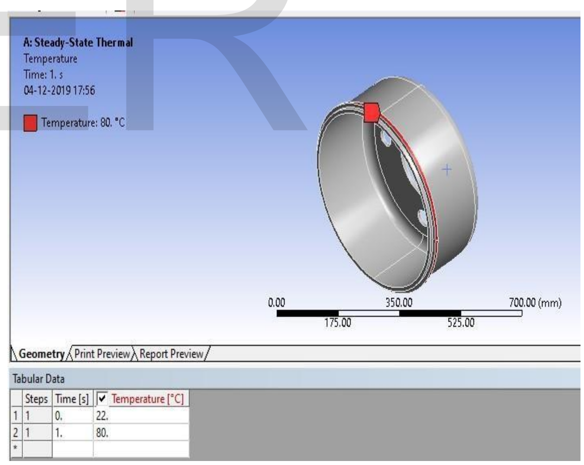


Fig 4: Application of Temperature

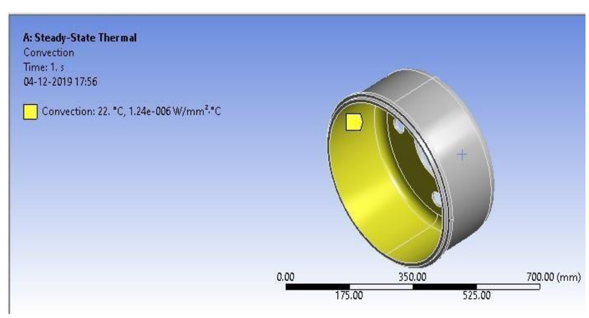


Fig 5: Convection at 22 °C

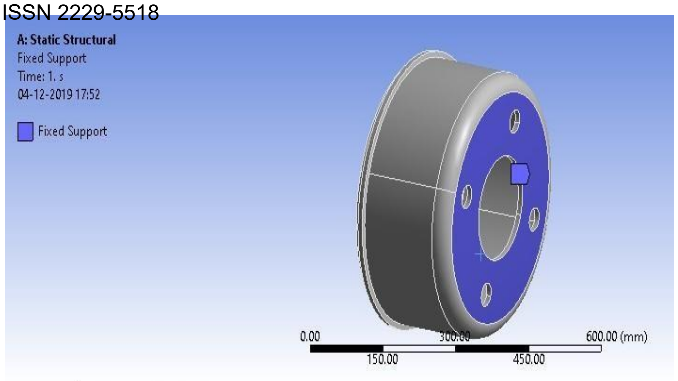


Fig 7: Fixed support

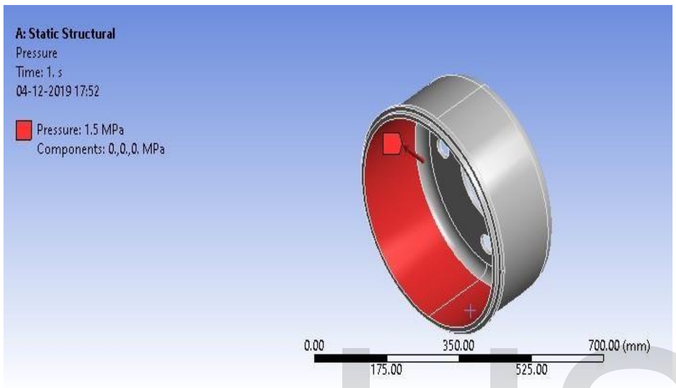


Fig 8: Application of Pressure

5. MATERIALS AND THEIR PROPERTIES

Aluminium Alloy,Grey Cast Iron and Structural Steel are considered for testing of thed brake drum in Ansys at different conditions.

Table 2: Properties of Materials

Material	Density (kgm^3)	Young's modulus (MPa)	Poisons ratio	Thermal conductivity(w/mK)
Grey Cast iron	7200	110000	0.28	52
Aluminium alloy	2770	71000	0.33	148.5
Structural Steel	7850	200000	0.3	60.5

6. Results

A. Aluminium alloy at 110ºC Temperature and 5MPa Pressure

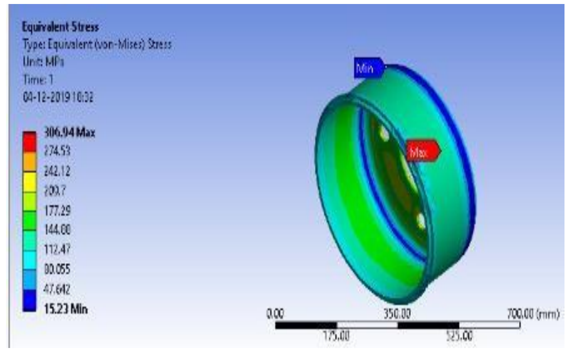


Fig 9: Von-mises stress (Al 1)

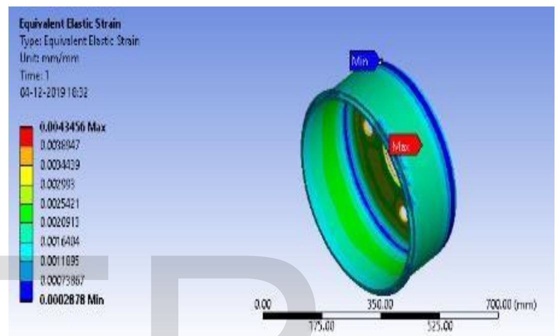


Fig 10: Elastic Strain (Al 1)

The brake drum has maximum and minimum stress of 306.94MPa and 15.23MPa and maximum and minimum strain of 0.0043456 and 0.000287 as shown in fig 9 and fig 10

.

B. Aluminium alloy at 120 ºC Temperature and 7.5MPa Pressure

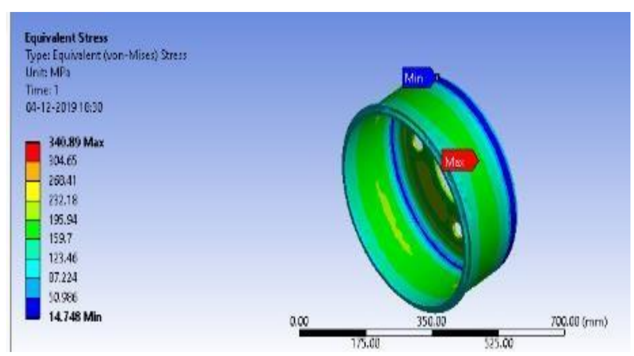


Fig 11: Von-mises stress (Al 2)

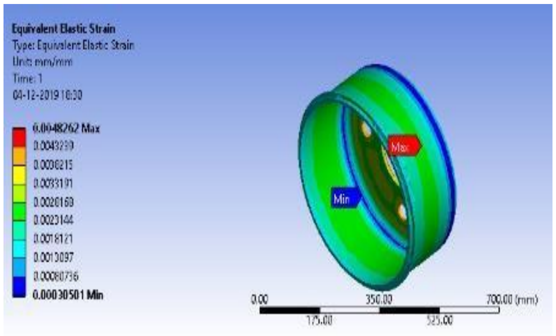


Fig 12: Elastic Strain (Al 2)

The brake drum has maximum and minimum stress of 340.89MPa and 14.748MPa and maximum and minimum strain of 0.0048262 and 0.00030501 as shown in fig 11 and fig12.

C. Grey Cast iron at 110 ºC Temperature and 5MPa Pressure

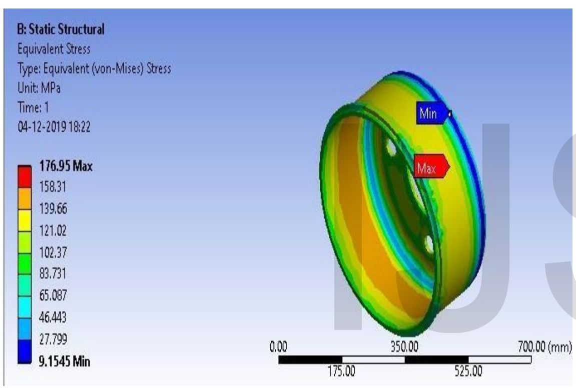


Fig 13: Von-mises stress (Ci 1)

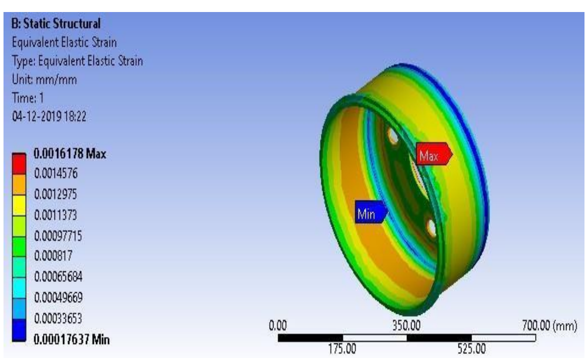


Fig 14: Elastic Strain (Ci 1)

The brake drum has maximum and minimum stress of 176.95MPa and 9.1545MPa and maximum and minimum strain of 0.0016178 and 0.00017637 as shown in fig 13 and fig 14.

D. **Grey Cast iron at 120 ºC Temperature and 7.5MPa Pressure**

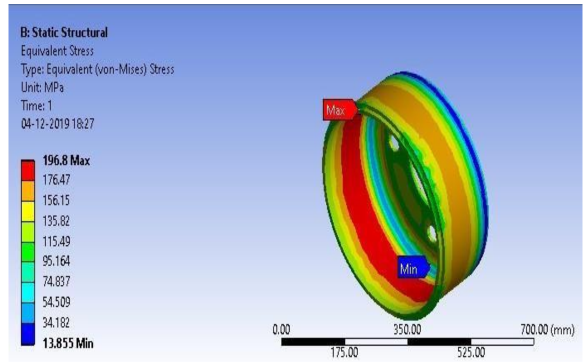


Fig 15: Von-mises stress (Ci 2)

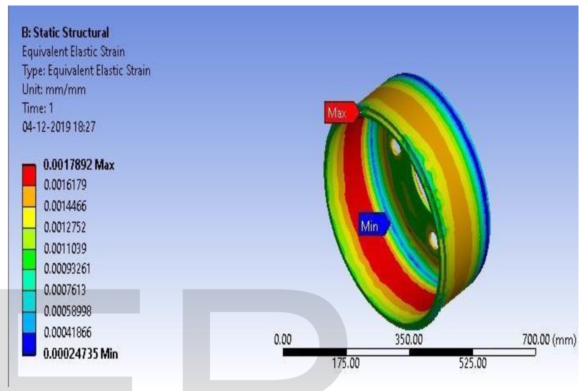


Fig 16: Elastic Strain (Ci 2)

The brake drum has maximum and minimum stress of 196.8MPa and 13.855MPa and maximum and minimum strain of 0.0017892 and 0.00024735 as shown in fig 15 and fig 16.

E. Structural Steel 110 °C Temperature and 5MPa Pressure

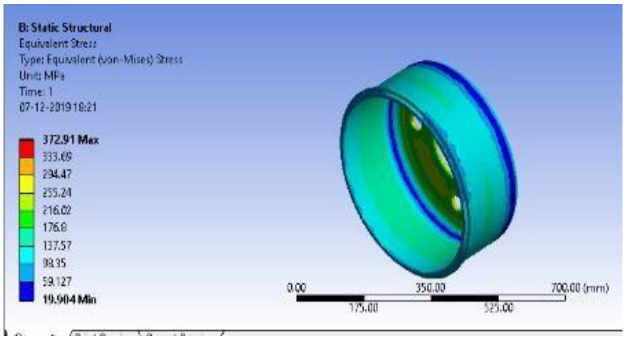


Fig 17: Von-mises stress (SS 1)

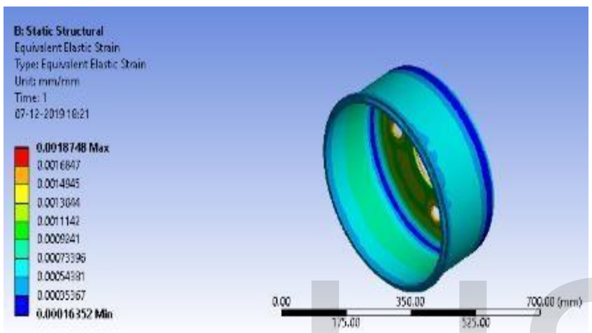


Fig 18: Elastic strain (SS 1)

The brake drum has maximum and minimum stress of 372.91MPa and 19.904MPa and maximum and minimum strain of 0.0018748 and 0.00016352 as shown in fig 17 and fig 18.

F.Structural Steel at 120°C Temperature and 7.5MPa Pressure

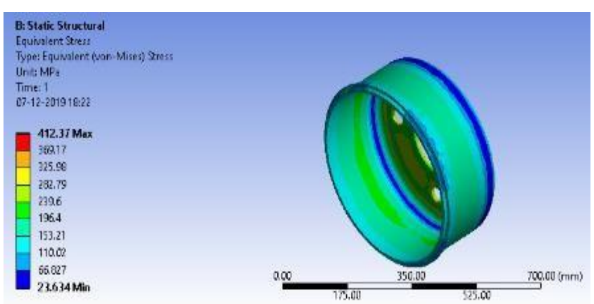


Fig 19: Von-mises stress (SS 2)

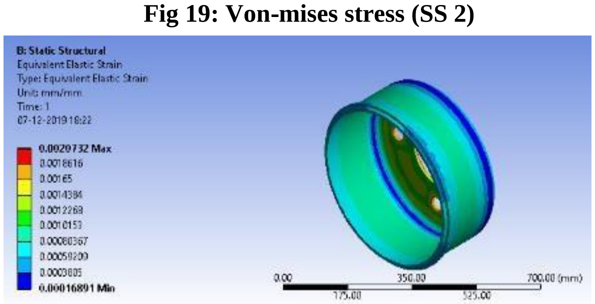


Fig 20: Elastic Strain (SS2)

The brake drum has maximum and minimum stress of 412.37MPa and 23.634MPa and maximum and minimum strain of 0.0020732 and 0.00016891 as shown in fig 19 and fig 20.

Tab le 3: Statics of Trail results

Trails	Aluminium alloy		Grey cast iron	
	Maximum	Minimum	Maximum	Minimum
Stress (1) in MPA	306.94	15.23	176.95	9.1545
Strain (1)	0.0043456	0.0002878	0.0016178	0.00017637
Stress (2) in MPA	340.89	14.748	196.8	13.855
Strain (2)	0.0048262	0.00030501	0.0017892	0.00024735

Trails	Structurl steel	
	Maximum	Minimum
Stress (1) in MPA	372.91	19.904
Strain (1)	0.0018748	0.00016352
Stress (2) in MPA	412.37	23.634
Strain (2)	0.0020732	0.00016891

G . Validation

We validate trail results by taking ford figo specifications

Wheel base (b) = 2491mm
Height (h) = 1525mm
Diameter = 460mm
Weight (W) =1078kg
Weight Transferred W_t = Wμhf/bg
Where f=μg
Then $W_t=\mu^2 hW/b$
$W_t= 0.6^2*1525*W/2491$
$W_t=0.22W$
$W_t=0.22*1078*9.81$
$W_t=2330.7N=F$

Force of 2330.7N is applied on drum brake with 120 °C Temperature and obtain results.

a.Aluminium alloy

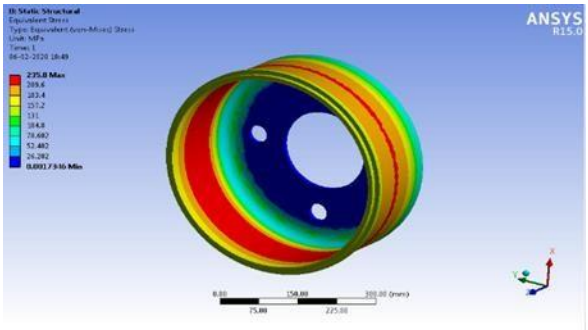


Fig 21: Von-mises stress (Al)

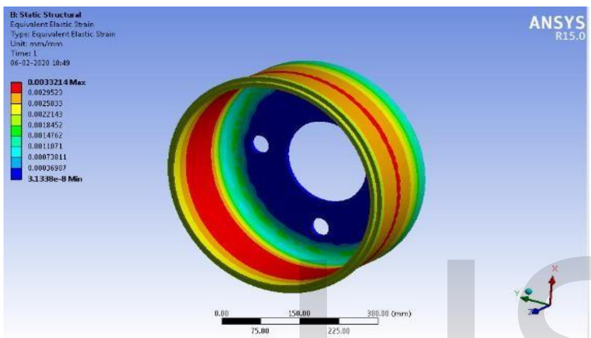


Fig 22: Elastic strain (Al)

The brake drum has maximum and minimum stress of 235MPa and 8.0017346MPa and maximum and minimum strain of 0.003321 and 3.1338e^{-8} as show in fig 21 and fig 22..

b.Grey Cast iron

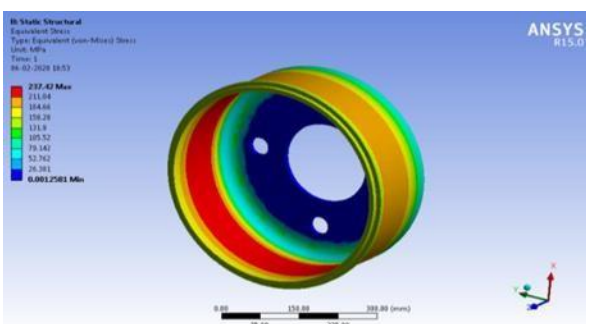
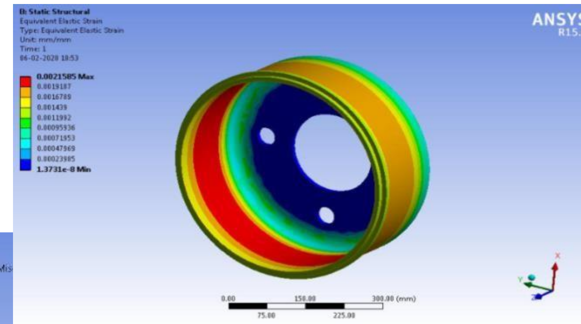


Fig 23: Von-mises stress(Ci)



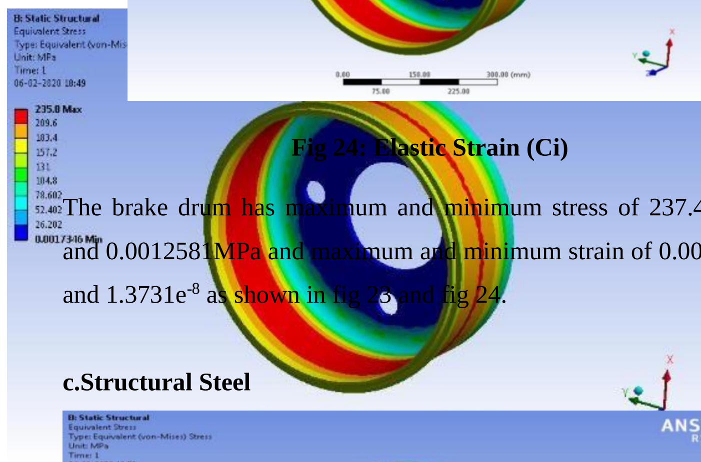


Fig 24: Elastic Strain (Ci)

The brake drum has maximum and minimum stress of 237.42MPa and 0.0012581MPa and maximum and minimum strain of 0.0021585 and 1.3731e^{-8} as shown in fig 23 and fig 24.

c.Structural Steel

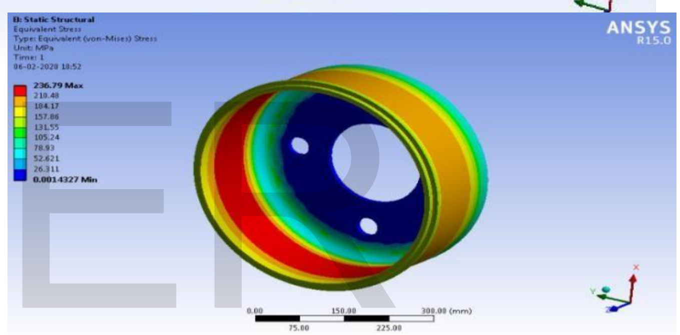


Fig 25:Von-mises stress(SS)

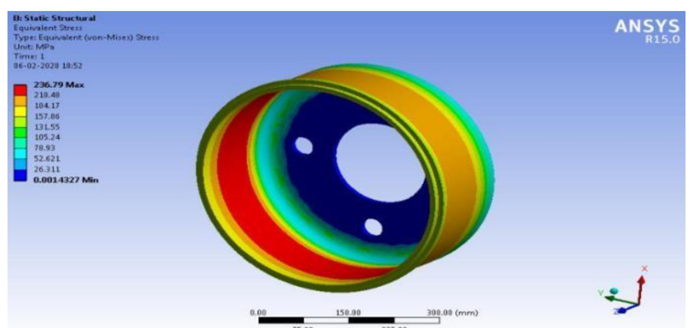


Fig 26:Elastic strain (SS)

The brake drum has maximum and minimum stress of 236.79MPa and 0.0014327MPa and maximum and minimum strain of 0.001184 and 8.8147e^{-9} as shown in fig 25 and fig 26.

Table 4: Ford Figo result statics

Material	Aluminium alloy		Grey Cast Iron	
	Min	Max	Min	Max
Stress in MPa	0.00173	235.8	0.00125	237.42
Strain	$3.133*10^{-8}$	0.0033	$1.37*10^{-8}$	0.0021

Material	Structural steel	
	Min	Max
Stress in MPa	0.0014	236.79
Strain	$8.81*10^{-9}$	0.00143

7 Conclusion

The drum brake model is subjected to structural and thermal analysis and results of stress, strain are tabulated.Results indicate that stress and strain is good enough in grey cast iron compared to other materials.We conclude that grey cast iron is the best material for the manufacture of brake drum in automobiles.

Acknowledgment

I thank Dr. Niranjan Hiremath associate professor in REVA university for helping in publishing the journal.

References

1] Vytenis Surblys, Edgar Sokolovskij, ― Research of the vehicle brake Test Efficiency ‖, 2015.

[2] Abhishek Patel, A.K Jain, ―Design and analysis of brake drum Shoe Lining by fea: A review‖, 2018.

[3]Anup Kumar, R.Sabarish, ―Structural and Thermal analysis of Brake Drum‖,2014.

[4] Meenakshi Kushal, Suman Sharma, ―Optimization of Design of Brake Drum of Two Wheeler through Approach of Reverse Engineering by Using Ansys Software‖, 2015.

[5]P Venkataramana, ―Design of Brake Drum Using Finite Element Method‖, 2013.

[6]C.Bala Manikandhan, P Balamurugan, S.Lionel Beneston, S.Balamurugan, ―Braking Force and Braking Time Reduction by using Four Shoe Brake System‖, 2019.

[7]Nouby M.Ghazaly, Mosthafa M.Makrahy, ―Experimental investigation of Drum Brake Performance for passenger Car‖, 2014.

[8]Aravind P Jinturkar,‖Design Optimization of Hub-Cum Brake Drum for Weight Reduction‖.

[9] Amit Phatak, Prof. Prasad Kulkarni, ―Drum Brake Backplate Analysis and Design Modification to Control Squeal Noise‖, 2017.

[10] D. Rambabu. Gopinath, U. Senthil rajan, G.B. Bhaskar, ―Weight reduction of a standard brake drum: A design approach‖, 2014.

[11] Ramesh, Ananthapadmanabhan, Sundar, Sriram, ―Analysis of drum brake defects as a source of automotive vibro-acoustics‖, 2019.

[12] Bako Sunday, Borı Ige, Musa Nicholas, Nasır Abdulkarim, ―IMPROVEMENT OF HEAT DISSIPATION RATE OF AN AUTOMOBILE BRAKE DRUM USING FINS INCORPORATION‖, 2018.