Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 4, Issue 5, May -2017

Design and Analysis of Al 356.2 and ZK60A Wheel Rim with Radial and Spiral Flexures

M. Mohamed Lukhman[1], Naveen Kumar M[2], Venkatesan J[2], Sathish kumarS[2], Srinavinapriya D[2]

[1]*Assistant Professor, Department of Mechanical Engineering, Karpagam Institute of Technology*
[2]*UG Scholar, Department of Mechanical Engineering, Karpagam Institute of Technology*

Abstract *—In the present state of affairs, light weight wheel rim plays a surpassing role in automobile which has to withstand high stress. The stress on the wheel rim may be subjected to bending and torsional loadings. Improvement in design of rim emphasis high stress withstanding capacity, long life, steering control andthere by reduces the weight of the rim and unsprung weight of the vehicle which again assists in less consumption of fuel. Wheels may be made of cast aluminium alloy or Mg alloy are widespread to their aesthetics and lighter weight compared to steel wheel rims. In this project work, a parametric model of wheel rim of Al 356.2 and ZK60A alloys were designed with radial and spiral flexures using CREO. Design is analysed using ANSYS software on bending and radial endurance tests as key aspects in accordance with the specifications prescribed in the industrial standards. From the results, it is found that factor of safety for Al 356.2 and ZK60A with spiral flexure is greater than radial flexure.*

Keywords: *wheel rims, Al 356.2, ZK60A, Creo, Ansys and Endurance tests.*

I. INTRODUCTION

In an Automobile industry, the main objective of the Wheel rim is to be sturdy enough to support the vehicle and to stand up the forces caused by traditional operation. At an equivalent time, they have to be as light-weight as attainable and to assist it must keep un-sprung weight to a minimum. Wheels may be made of cast aluminium alloy or Mg alloy. Alloy wheel rims are widespread to their aesthetics and lighter weight compared to steel wheel rims. Latest Innovations have shown that up to 50% weight saving can be achieved by the substitution of steel by aluminium. This can result in a 20–30% total vehicle weight reduction when added to other reduction opportunities. The cost of Aluminium alloy and value stability remains its biggest hindrance for its use in large-scale applications. Aluminium alloy has targeted the automotive trade for future growth and has devoted vital resources to support this effort. Aluminium is a higher conductor of heat; therefore al alloy wheel rims will dissipate heat from brakes and tyres effectively than steel ones. Most wheel rims have ventilation holes within the rim, therefore air will flow into to the brakes [1]. Magnesium wheel is about 30% lighter than Al and also, glorious for size stability and impact resistance. Recently the technology for casting and shaping is improved and therefore the corrosion resistance of metal is additionally rising. Magnesium alloy possesses enticing properties compared to Al alloys such as low density, high specific strength and high cast ability; conjointly it also facilitates engrossing vibration and damping the noise emission. The wheel rim, together with the tire has got to take the vehicle load, offer a padding impact and deal with the steering management. The varied needs of associate in nursing automobile wheel are:
• It ought to be balanced statically and dynamically
• It ought to be lightest attainable.
• It ought to be attainable to get rid of or mount the wheel simply.
• Its material should not disintegrate.
In this paper authors have tried to check concerning rims of varied materials i.e.Al 356.2 and ZK60A with various designs (Radial flexures and Spiral flexures). The choice of material used for rim is vital as rim style plays a significant role within the performance of vehicle.

II. LITERATURE REVIEW

This section elaborates literature review on the substantial development in design and Analysis of alloy wheel rim:
The Aluminium Automotive Manual (2011) has studied the assorted sorts of wheel rim materials with itsadvantageous, disadvantages, rim producing processes, mechanical properties of materials, metal sheetmetal wheel rims additionally as basic necessities of rim. However analysis is proscribed to solely aluminium material and notexplained the opposite sorts of materials. As per this manual basic necessities strength, structural stiffness, fatigue behaviour and crash worthiness etc. [2].
M. Sabari et.al (2015) has prepared the comparative study of wheel rim materials for its deformation with thehelp of FEA strategies. In his study he contemplated two different materials specifically steel and aluminium alloy. CADmodel of each material has been drafted by Solid works and analysed by CATIAsoftware. During this analysis investigator modified the two parameters like load applied and speed of wheel rim. Bychanging load and cruising speed rims has analysed additionally graph of most displacement against speed premeditated andit is found that

as speed will increase displacement of each material will increase. Displacement in Al alloy wheel rim is a lot ofthan the steel [3].

S. Ganesh et.al (2014) has studied the Al 356.2 Al alloy wheel for spiral wheel rim used for four wheel vehicles and given the properties of assorted rim materials with some drawbacks. In his work, researcher said that magnesium rims are strong enough however not appropriate for off road vehicles; nonetheless they're employed in a Mercedes-G automobile models, just one huge disadvantage of Magnesium material is bent rim cannot be repaired thus such rims directly fall in scrap[4].

III. THEORICAL ASPECT OF A PROBLEM

3.1 Geometric Modelling of wheels:

The solid model of the wheel rim with radial and spiral flexures has been designed using CREO software in accordance with industrial standards.

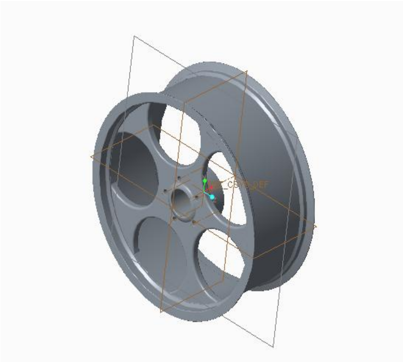

Fig 1: Radial wheel rim

Fig 2: Spiral wheel rim

3.2 Meshing:

After designing a model, the wheel rim is transferred to the ANSYS using IGES translator and then meshed with the model 10-noded tetrahedral solid components

3.3 Material Properties:

The mechanical properties of Al 356.2 and Zk60A are as follows:

Table 1: Mechanical properties of Al 356.2 and Zk60A

Description	**Al 356.2**	**Zk60A**
Ultimate strength	228 MPa	340 MPa
Density	2.7 Kg/m^3	1700 Kg/m^3
Yield strength	166 MPa	260 MPa
Composition	Silicon- 6.5-7.5% Iron- 0.12% Manganese -0.05% Magnesium- 0.3-0.45% Zinc- 0.50% Titanium - 0.20% Copper- 0.10% Others- 0.15% Remaining Aluminium	Zinc 4.8-6.2% Zirconium 0.65%min Magnesium balance

IV. DESIGN CALCULATION:

4.0 Bending test

The bending moment to be imparted in the test shall be in accordance to the following formula:

$$M = ((\mu * R) + d) * F * S$$

M = Bending moment in 'Nm'
μ = Friction - Coefficient between the tyre and the road surface (no units)
R = Radius of the tyre applicable to the wheel in 'm'-50mm=0.050m
d = Offset of the wheel in 'm'
F = Maximum load acting on the tyre in 'N'
S = Coefficient specified according to the standards.

Tyre specification Radial 178/60-R19
178 is the section width in millimetres
60 is the Aspect ratio in percentage
R is the construction type i.e.,
Radial 19 is the rim diameter in inches
Aspects ratio = section height / section width
Section height = Section width * Aspect ratio
= 178 * 0.60
= 106.8mm

= 0.106.8 m
Rim diameter = 17 inches
= 19 * 2.54 = 48.26 cm
Rim radius = 24.13 cm = 0.2413 m
Tyre radius = Rim Radius + Section height
= 0.2513 + 0.106.8
= 0.3913 m
According to the industrial standards:
μ = 0.7
d = 50 mm = 0.050 m
F=968 lbs.
= 968 * 0.453
= 439kg
= 439* 9.81
= 4306.5 N
S = 1.8
Bending moment M = ((μ*R) + d)* F * S
= ((0.7 * 0.3689) + 0.050) * 4306.5 * 1.8
= 2389.30 Nm

4.2 Radial endurance test

The radial load to be imparted in the test shall be in accordance with the following formula:
F_r = F * k
Where, F_r = Radial load in N
F = the maximum load N
K = Coefficient according to the industrial standards
According to the industrial standards
F = 968 lbs.
= 968 * 0.453
= 439 kg
= 4306.5*2.25
=9689.625N
Radial Load = F * k
= 9689.625 * 2.25
= 21801 N

V. LOAD CASE EXPLANATION

5.1Load Case Bending

In the bending case, a vertical load of 2389.30 N is applied at a distance of 1 m from the middle of the hub. Before applying the load, the model ought to be meshed property and all the degrees of freedom should be arrested.. The outer rim is chosen by means of a range set and displacement is outlined through node by considering the conditions. The load is applied to the node in Y direction (downward direction) when the constraints are specified for the model. The forces are premeditated on the screen using command FPLOT. Before running the analysis the model ought to be feed with decent information like material property like density, Poisson's ratio, Young's modulus, real constants and element group. Aluminium alloy (A 356.2) is selected as material for our model with density 2700 kg/m3, Poisson's ratio 0.3 and Young's modulus of 67500 kg/m^2similarly for Zk60A. Under element group it is necessary to ascertain the attributes of components prescribed in the model and then the data's are checked using DATA CHECK command. With the help of analysis option, the desired analysis (RUN STATIC ANALYSIS) is created to endure the model and the necessary results are premeditated

5.1.1 Case Bending-Stress

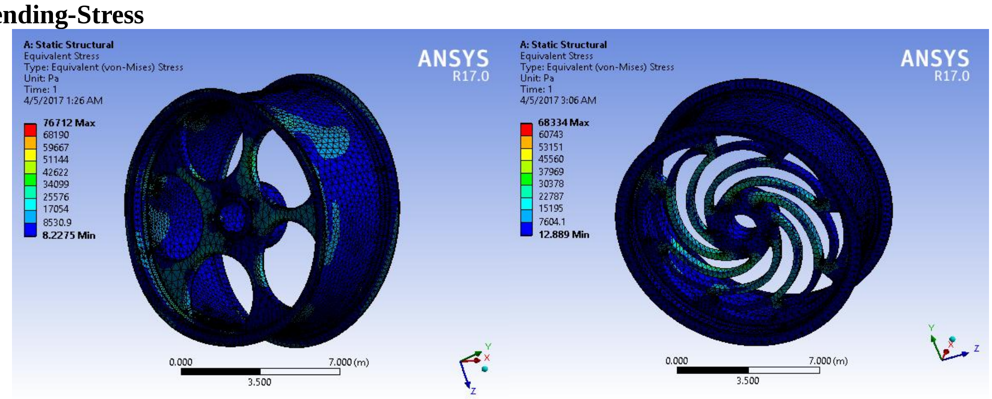

Fig 3: Load case Bending - Stress (a) Radial Al 356.2 (b) Spiral Al 356.2

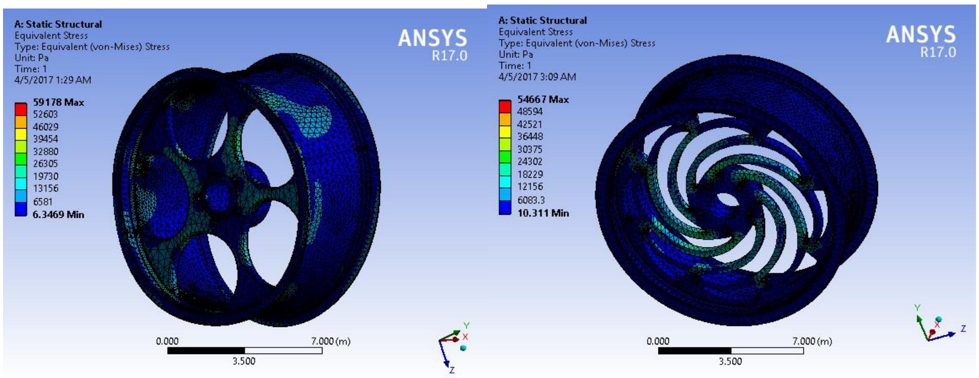

Fig 4: Load case Bending - Stress (a) Radial ZK60A (b) Spiral ZK60A

5.1.2 Case Bending-Strain:

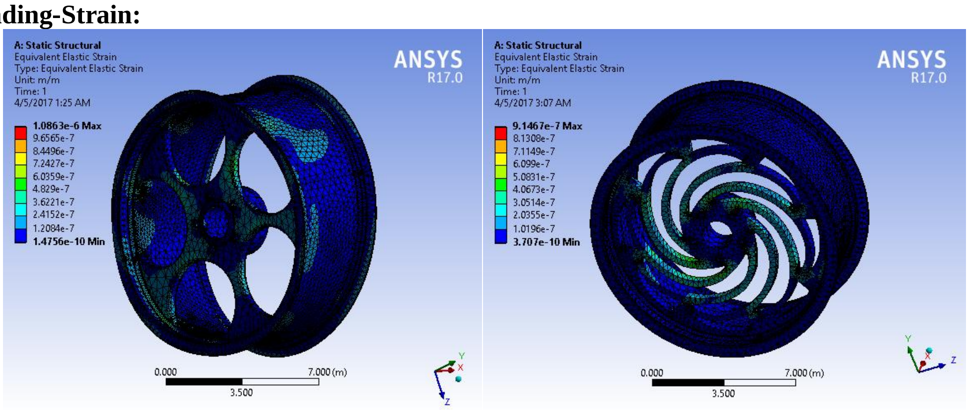

Fig 5: Load case Bending - Strain (a) Radial Al 356.2 (b) Spiral Al 356.2

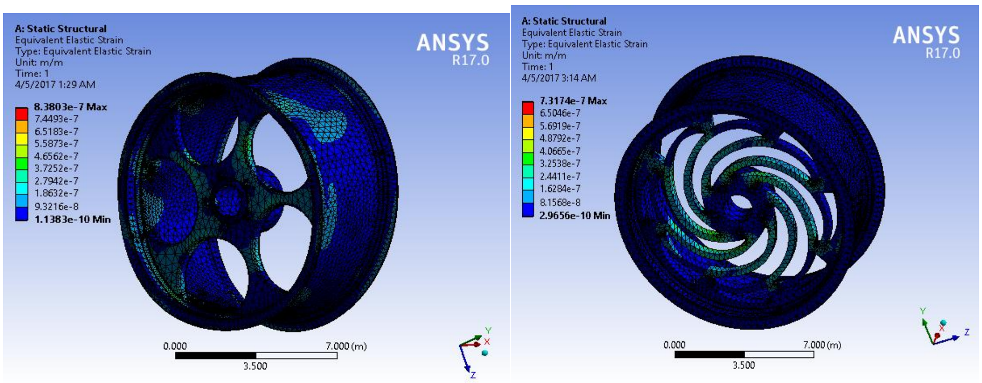

Fig 6: Load case Bending - Strain (a) Radial ZK60A (b) Spiral ZK60A.

5.1.3Case Bending-Deformation:

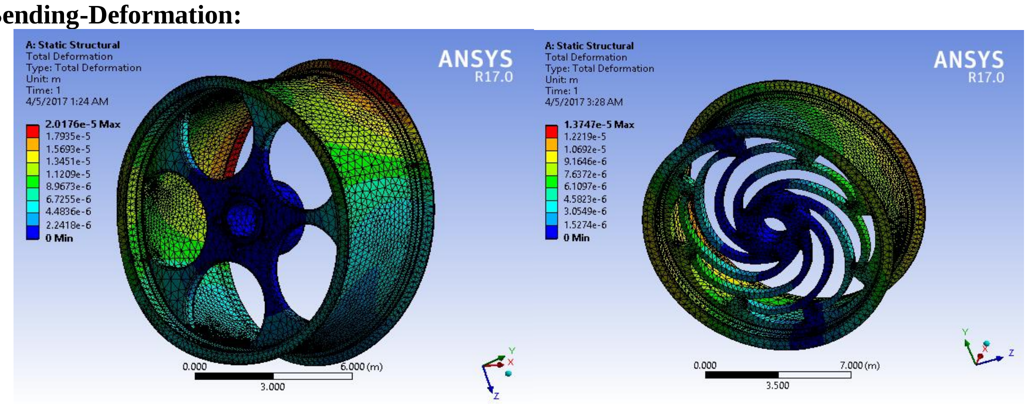

Fig 7: Load case Bending - Deformation(a) Radial Al 356.2 (b) Spiral Al 356.2

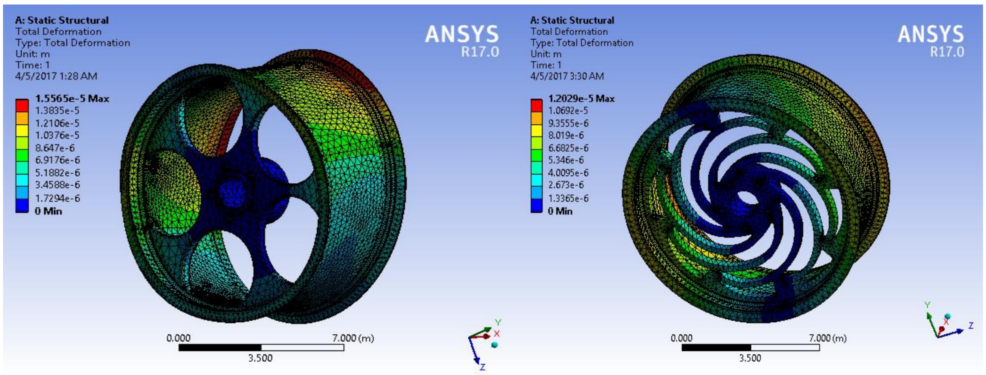

Fig 7: Load case Bending - Deformation (a) Radial ZK60A (b) Spiral ZK60A.

5.2 Load Case Pressure

In case of pressure loading, the pressure of 3.5 kg/cm^2 is applied through the circumference of the wheel and bolts are constrained for all six degrees of freedom. The bolt is chosen by means of a various set and displacement is outlined by means of nodes by considering the conditions as prescribed above. The load is applied to the node in Y direction (downward direction) after the constraints are specified for the model. The forces are premeditated on the screen using the command FPLOT. Before running the analysis the model should be feed with information such as material property, the property such as Density, Poisson's ratio, Young's modulus should be given as data for material, which have been selected for the model. Aluminium alloy (A 356.2) is chosen as a material for our model with density 2.7E-6 kg/ mm^3, Poisson's ratio 0.3 and young's modulus of 0.675E5kg/mm^{2}similarly for Zk60A. Under element group it is necessary to ascertain the attributes of componentsoutlined. RUN CHECK does more elaborate checking including element connectivity. With the employment of analysis option, the desired analysis (RUN STATIC ANALYSIS) is made to run for the model and the necessary results are premeditated.

5.2.1Case Pressure-Stress

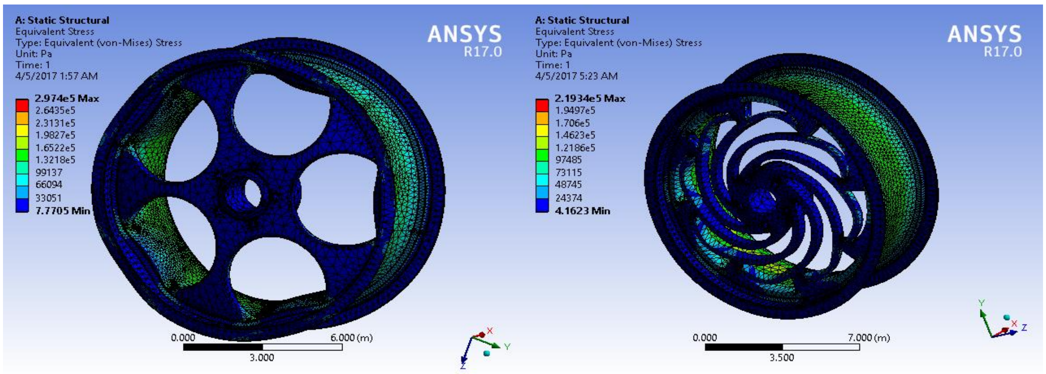

Fig 8: Load case pressure- Stress (a) Radial Al 356.2 (b) Spiral Al 356.2

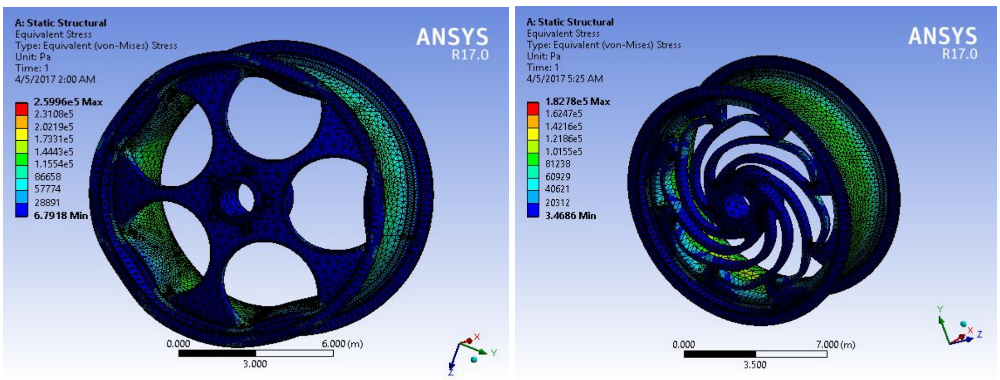

Fig 9 : Load case pressure - Stress (a) Radial ZK60A (b) Spiral ZK60A.

5.2.2 Case Pressure-Strain

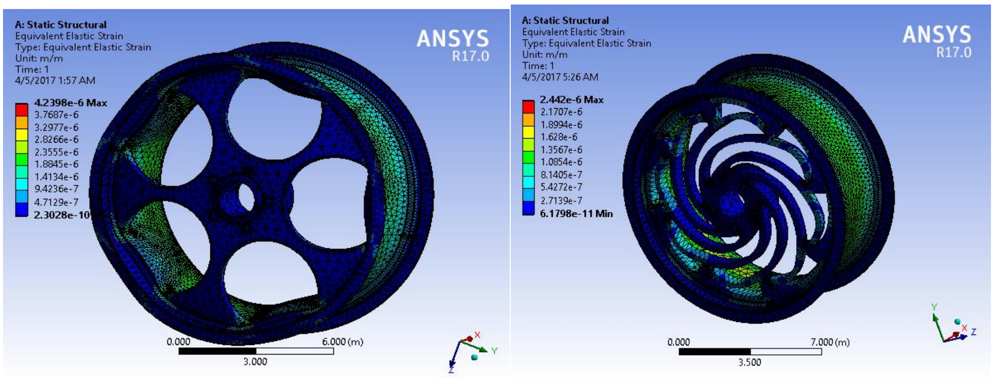

Fig 10: Load case pressure - Strain (a) Radial Al 356.2 (b) Spiral Al 356.2

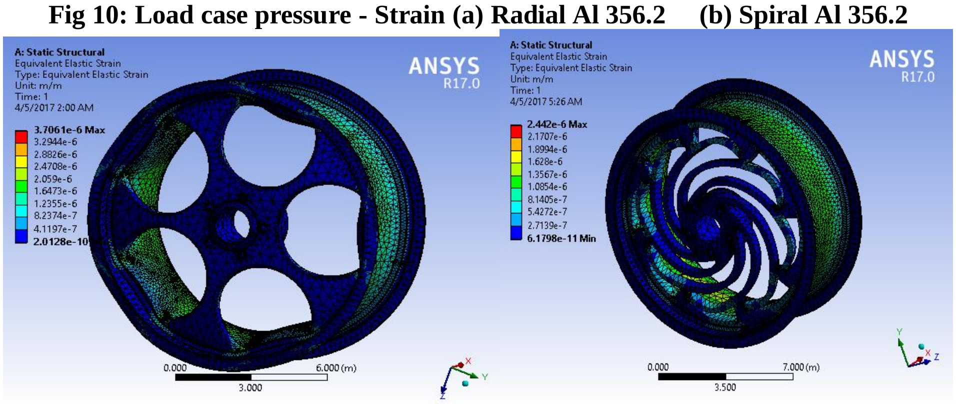

Fig 11: Load case pressure - Strain (a) Radial ZK60A (b) Spiral ZK60A.

5.2.3 Case Pressure Deformation:

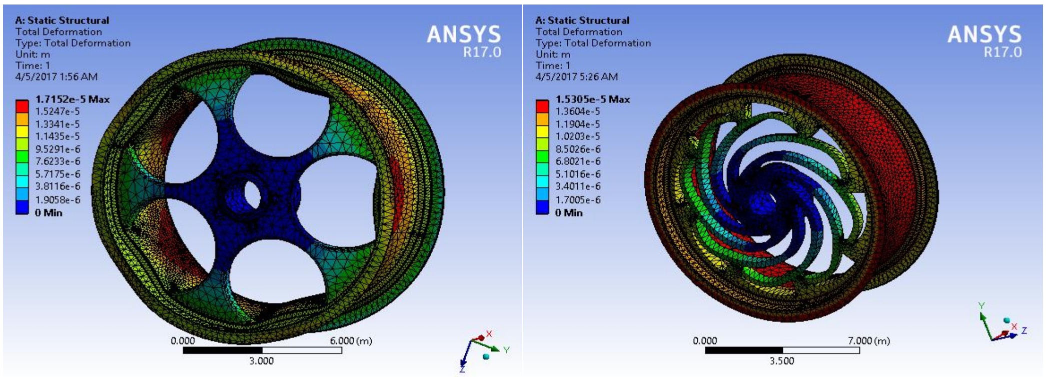

Fig 12: Load case pressure - Deformation (a) Radial Al 356.2 (b) Spiral Al 356.2

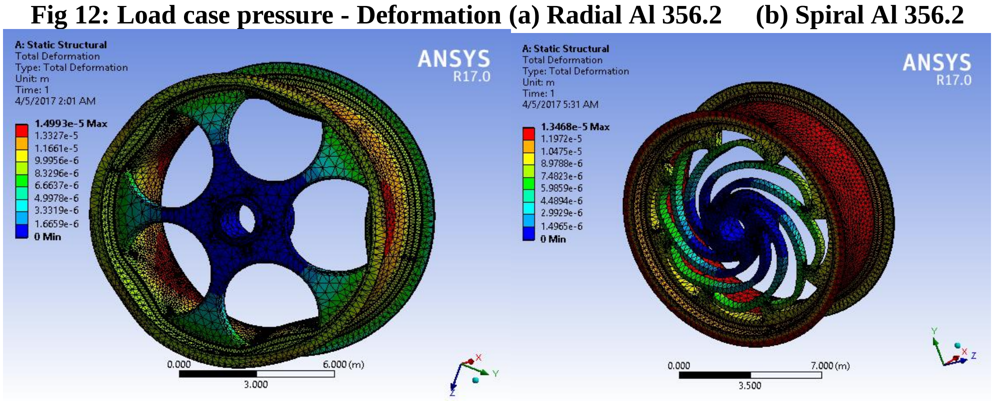

Fig 13: Load case pressure - Deformation (a) Radial ZK60A (b) Spiral ZK60A.

5.3 Load Case Vertical

In the vertical case, a vertical load of 21,801 N is applied vertically from downwards. Before applying the load, the model ought to be meshed property and all the degrees of freedom should be arrested. The outer rim is chosen by means of a range set and displacement is outlined through node by considering the conditions.. The load is applied to the node in Y direction (downward direction) when the constraints are specified for the model. The forces are premeditated on the screen using command FPLOT. Before running the analysis the model ought to be feed with decent information like material property like density, Poisson's ratio, Young's modulus, real constants and element group. Aluminium alloy (A 356.2) is selected as material for our model with density 2700 kg/m3, Poisson's ratio 0.3 and Young's modulus of 67500 kg/m^2 similarly for Zk60A. Under element group it is necessary to ascertain the attributes of components prescribed in the model and then the data's are checked using DATA CHECK command. With the help of analysis option, the desired analysis (RUN STATIC ANALYSIS) is created to endure the model and the necessary results are premeditated.

5.3.1 vertical load – stress

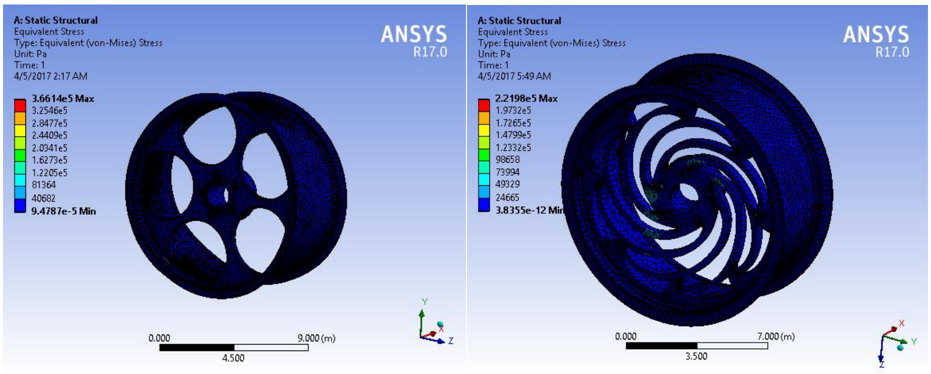

Fig 14: Load case Vertical - Stress (a) Radial Al 356.2 (b) Spiral Al 356.2

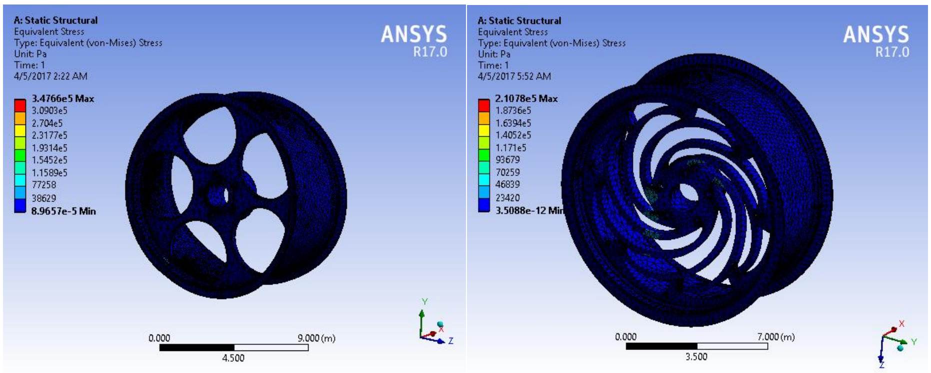

Fig 15: Load case Vertical - Stress (a) Radial ZK60A (b) Spiral ZK60A.

5.3.2 vertical load – strain

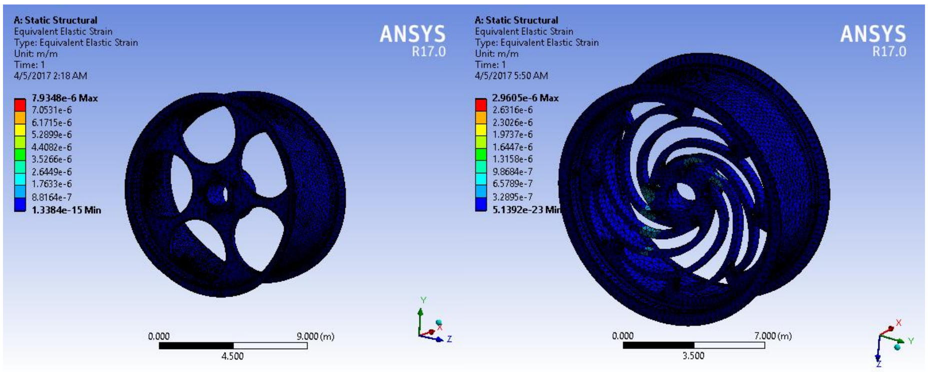

Fig 16: Load case vertical - strain (a) Radial Al 356.2 (b) Spiral Al 356.2

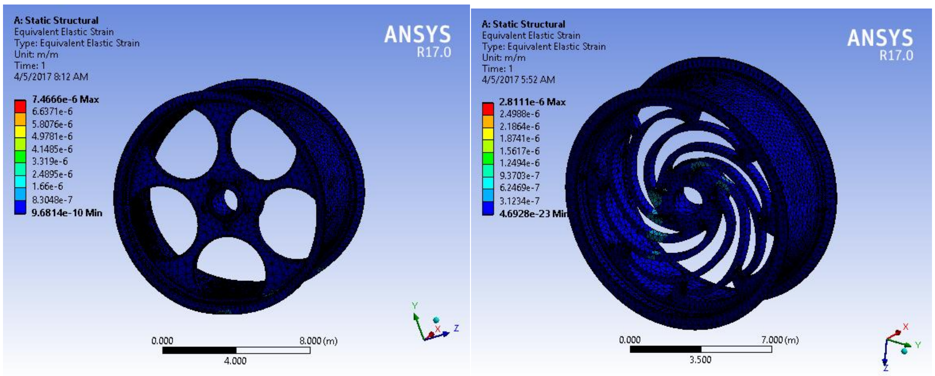

Fig 17: Load case vertical - strain (a) Radial ZK60A (b) Spiral ZK60A.

5.3.2 vertical load – Deformation

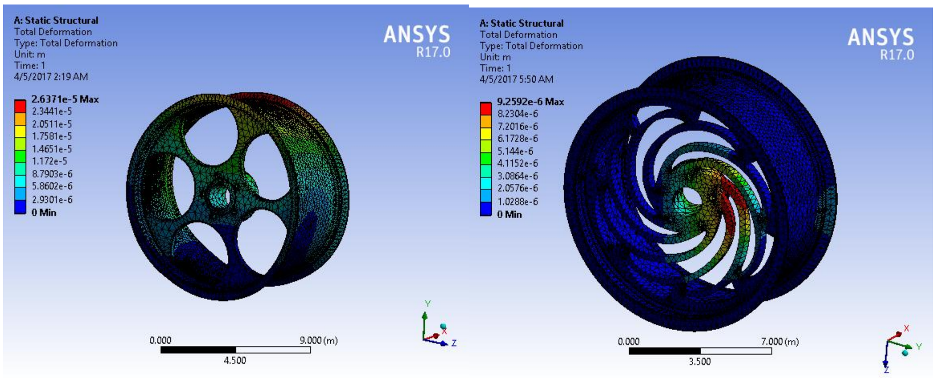

Fig 18: Load case vertical - Deformation (a) Radial Al 356.2 (b) Spiral Al 356.2

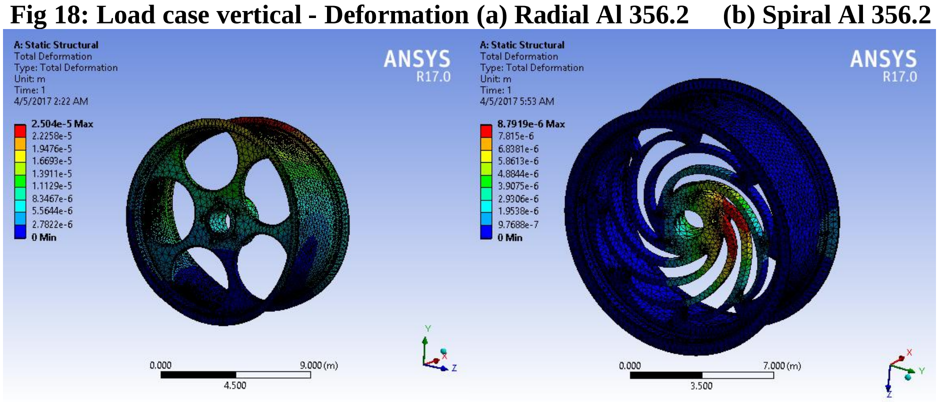

Fig 19: Load case vertical - Deformation (a) Radial ZK60A (b) Spiral ZK60A.

VI. RESULTS AND SUMMARY

Table 2: Comparison of stress, strain and deformation of Al 356.2 and ZK60A alloys

Rim material	Types of flexure	Types of loading	Stress (MPa)	Strain	Displacement
Al 356.2	Radial	Case bending	76.7	0.00010	2.01×10^{-5}
	Spiral		68	0.00009	1.37×10^{-5}
ZK60A	Radial		59	0.00008	1.55×10^{-5}
	Spiral		54	0.00007	1.20×10^{-5}
Al 356.2	Radial	Case pressure	29.7	0.00004	1.71×10^{-5}
	Spiral		21	0.00003	1.53×10^{-5}
ZK60A	Radial		25	0.00003	1.49×10^{-5}
	Spiral		18	0.00002	1.34×10^{-5}
Al 356.2	Radial	Vertical loading	3.6	0.000007	2.63×10^{-5}
	Spiral		2.2	0.000002	0.92×10^{-5}
ZK60A	Radial		3.47	0.000007	2.5×10^{-5}
	Spiral		2.1	0.000002	0.87×10^{-5}

Table 3: Factor of Safety

Rim material	Types of flexure	Factor of safety
Al 356.2	Radial	2.16
	Spiral	2.44
ZK60A	Radial	4.06
	Spiral	4.44

The results obtained from the Fig and Table are as follows:

(i) In the bending case, for a vertical load of 2389.30 N applied at a distance of 1 m from the middle of the hub; stress, strain and total deformation of ZK60A with spiral flexure is minimum compared to Al 356.2 , ZK60A and Al 356.2 with radial flexures.

(ii) In case of pressure loading, for the pressure of 3.5 kg/cm^2 applied through the circumference of the wheel; ; stress, strain and total deformation of ZK60A with spiral flexure is minimum compared to Al 356.2 , ZK60A and Al 356.2 with radial flexures.

(iii) In the vertical case, for a vertical load of 21,801 N is applied vertically from downwards; stress, strain and total deformation of ZK60A with spiral flexure is minimum compared to Al 356.2 ,ZK60A and Al 356.2 with radial flexures.

(iv) It is found that factor of safety for Al 356.2 and ZK60A with different flexures is greater than 2. The stress is with in permissible limit. Hence the design is safe under provided loading conditions.

VII. CONCLUSION

CAD model of the automobile wheel rim is designed in CREO software and analysed using Ansys software on bending and radial endurance tests as key aspects in accordance to the specifications prescribed in the industrial standards. A vertical load of 2389.30 N applied at a distance of 1 m from the middle of the hub for bending test, a pressure of 3.5 kg/cm^2 applied through the circumference of the wheel for pressure loading and a vertical load of 21,801 N is applied vertically from downwards for vertical radial endurance test for Al 356.2 and ZK60A with different flexures. From the results it is concluded that the stress of Al 356.2 and ZK60A alloys subjected to different test are within the permissible limit. Hence the design is safe under provided loading conditions and it is found that ZK60A with spiral flexures is the best option. The drawback in this ZK60A wheel rim is it cannot be applied in off-road applications.

REFERENCES

[1]R.B.Gupta, “Automobile Engineering”, Tech India Publication Series.

[2] “The Aluminium Automotive Manual”, Version 2011 European aluminium association. http://www.european-aluminium.eu/wp-content/uploads/2011/11/AAM-Applications-Chassis-Suspension-3- Wheels.pdf

[3]. M. Sabri, M. Rezal, A. Mu’az, K. Shahril, J. Ihsan, “Deformation Behaviour analysis of Car Wheel Rim under Different Loading Using Finite Element Method”, international Journal of Engineering and Technology, Volume 5, No.3, pp.- 181- 184, , March, 2015

[4]S. Ganesh and Dr. P. Periyasamy, “Design and Analysis of Spiral Wheel Rim for Four Wheeler”, the International Journal of Engineering and Science (IJES), Volume-3, Issue-4, Pages-29-37, 2014, ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805.

[5] Nitin S Gokhale, Practical Finite Element Analysis, 1999

[6] Sourav Das, "Design and Weight Optimization of Aluminium Alloy Wheel", InternationalJournal of Scientific and Research Publications, Volume 4, Issue 6, June 2014, ISSN 2250-3153