ISSN: 0974-5823 Vol. 7 No. 5 May, 2022

International Journal of Mechanical Engineering

MODELLING AND ANALYSIS OF CAR WHEEL RIM USING CAD/CAE TOOLS

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Abstract

The rim is the "outer edge of a wheel, holding the tire". It makes up the outer circular design of the wheel on which the inside edge of the tire is mounted on vehicles such as automobiles. In this work Kia carnival prestige vehicle wheel rim modelling and analyzing with CAD/CAE tools, here object developed with the help of solid works and then analyzed with structural and dynamic boundary conditions, and also the best material is suggested can withstand high speed maximum load boundary conditions. Here, Al-7075 and Al-7068 materials were chosen to analyze the properties.

Kia carnival prestige vehicle was chosen and analyzed with minimum load to maximum load boundary conditions i.e., for 3, 5 and 7 members load.

From result analysis it is observed that Al-7068 material is suitable for both conditions like structural and dynamic, and it has strength to weight ratio values, and also less in weight compare to Al-7075 material. This Al-7068 has very good natural frequency range values, and which withstand more vibrations than Al-7075, and also Al-7068 material has high safety factor values with least stress values, and this can increase the vehicle performance in terms of less fuel consumption due to less in weight and increase the durability of the object. Finally, it is concluded that Al-7068 material is best when compared to Al-7075 material.

1.0 Introduction

1.1 Wheel rim

The rim is the "outer edge of a wheel, holding the tire". It makes up the outer circular design of the wheel on which the inside edge of the tire is mounted on vehicles such as automobiles. For example, on a bicycle wheel the rim is a large hoop attached to the outer ends of the spokes of the wheel that holds the tire and tube. In cross-section, the rim is deep in the center and shallow at the outer edges,

2.0 LITERATURE REVIEW

- Kisshan, JL Miren, et al. "arranged and performed static and Eigenvalue Buckling examination on fabricated steel wheel rim and aluminum wheel rim. In both examination of made steel wheel edge and aluminum wheel edge, von-mises stresses are less diverged from outrageous strength. Redirections got more in aluminum edge than delivered steel edge. They wrapped up and leaned toward that delivered steel edge gave better results when appeared differently in relation to aluminum wheel edge.
- Ashok Kumar, G., et al. arranged a composite wheel in CATIA and performed examination by using ANSYS programming on wheel edge of TATA Indica. The static fundamental examination was proceeded with composite wheel by applying the three unmistakable materials specifically aluminum (AL 6061), zinc (ZA 21) and Magnesium (Mg). They saw similar weights and complete turning of compound wheels, and construed that most noteworthy outright misshapening and indistinguishable nerves are procured least for ZA 21 stood out from aluminum and magnesium.

3.0 Design Considerations and Calculations car wheel rim

Curb weight Kia carnival prestige= 4839lbs. → 2195 Kg s

Mass of Kia carnival prestige without wheel rim = net mass – (mass of wheel rim*4)

Let mass of wheel rim is 19.06bs → 8.65 Kg s

Mass of Kia carnival prestige without wheel rim (m) = 2195-34.6 Kg s = 2160.4 Kg s and assume it 2160 Kg s

Let us assume each person has maximum amount of mass (105 kg s).

For 3 members = 315kgs→ then total body = (2160+315kgs) = 2475kgs →24271N

For 5 members = 525kgs→ then total body = (2160+525kgs) = 2685kgs→26330N

For 7 members = 735kgs→ then total body = (2160+735kgs) = 2895kgs→28390N

3.1 Angular Velocity:

ω = V/r

V= 150km/hrs. = 41.66m/s

r = 0.229

ω= 181.92 rad/s

3.2 Wheel rim specifications

Wheel rim is designing by using these bellow specifications

Table 3.1 Wheel rim specifications

Car carnival prestige	
Car carnival prestige rim main diameter	458mm
Car carnival prestige Rim width	178mm
Car carnival prestige Rim shaft diameter	35mm
Car carnival prestige stud diameter	12mm
Car carnival prestige Thickness of wheel rim	6mm
Car carnival prestige Number of studs	4mm

4.0 SOLID WORKS DESIGNING PROCESS

Designing the wheel rim by using solid works 2018 SP05 software version, open the software and select part, then a new page is displayed. In that page design is developed by using the features, Sketch, Surfaces, Evaluate, Exit Sketch, Smart Dimension, Trim Entities, Offset Entities and Instant2D by using this option we build the wheel rim.

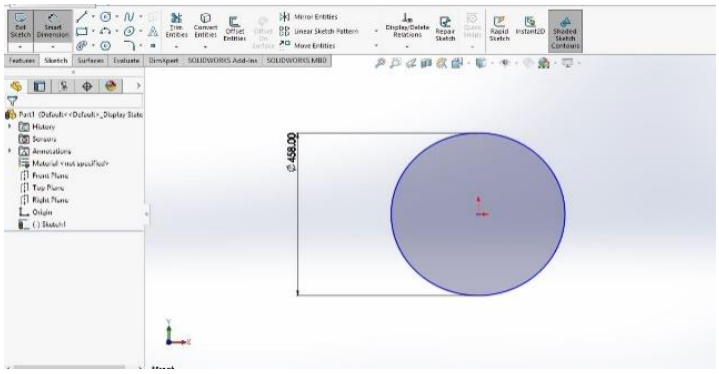

Fig: 4.1 Rim Drawn in Solid works with diameter 458mm.

Above image represents the Kia carnival prestige Rim main diameter value, and here outer diameter values mentioned as 458mm.

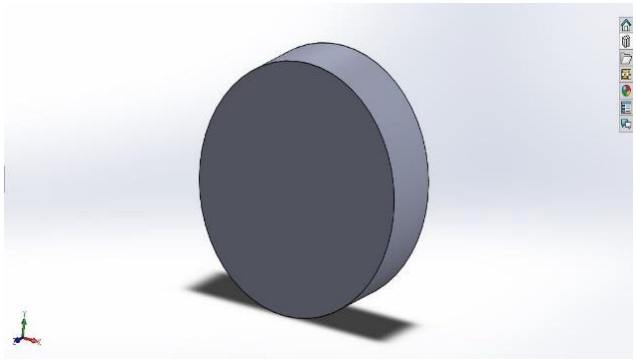

Fig: 4.2 3D Model of Rim

After completing diameter of Kia carnival prestige Rim, now exit and then select, extrude option to convert into 3D object, and enter length of the object as 178mm.

Fig: 4.3 Wheel rim final model

To create outer surface of the wheel rim, here used revolve cut option, and the final image shown in above.

5.0 STRUCTURAL ANALYSIS RESULTS

Material properties

Al-7075	Young's modulus	71.7E^9 Pa
	Poison ratio	0.33
	Density	2810 Kg/m^3
	Yield strength	503 Mpa
Al-7068	Young's modulus	73.25E^9 Pa
	Poison ratio	0.315
	Density	2770 Kg/m^3
	Yield strength	580 Mpa

5.1 Members boundary load conditions

Above wheel rim is converted in to small particles with the help of elements and nodes, and this entire process known as meshing, and this meshing helpful to solve the results of finite element analysis. Here elements and nodes quantity will change while increasing or decreasing the element size, if the element size is small then the elements and nodes quantity will be high, and if the element size is high and the elements and nodes, quantity will be low. When the element size is very small then the results will be more accurate to real time applications, and in this thesis, element size is used 1mm only. In addition, this meshing called as fine mesh.

After completing meshing process now select boundary conditions, and here boundary conditions were chosen as human weight and luggage weight, and also rotational velocity of the vehicle, here assumed vehicle is travelling at a speed of 150kmp/h, and then converted it to rotational velocity and the value is 181.92 rad/s, and the value is 3members load is 24271N. In addition, the object fixed at studs' position. All these boundary conditions applied areas and their values are shown in below image.

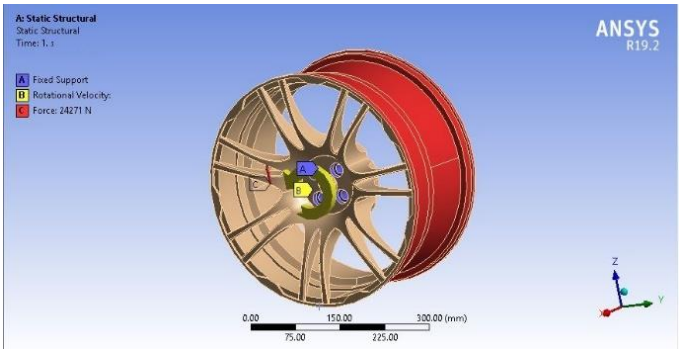

Fig: 5.1 Boundary condition for 3 members load.

Let us assume each person has maximum amount of mass (105kgs).

Select fixed support at studs, and then select rotational velocity and enter value as 181.92 rad/sec

For 3 members = →24271N apply and then solve

5.2 3 Members boundary load condition Deformation Results for Al-7075

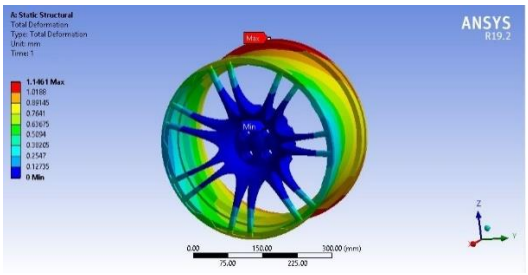

Fig: 5.2 3 Members boundary load condition Deformation Results for Al-7075

5.3 3 Members boundary load conditions Stress Results for Al-7075

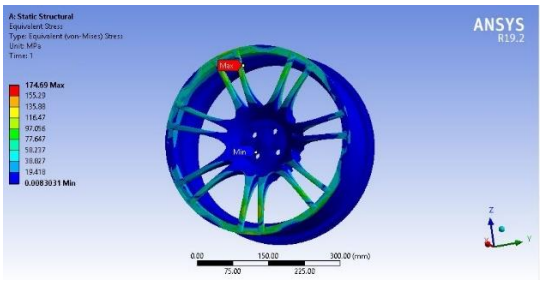

Fig: 5.3 3 Members boundary load condition Stress Results for Al-7075

5.4 3 Members boundary load condition Strain Results for Al-7075

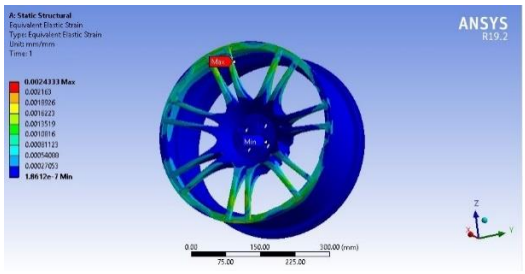

Fig: 5.4 3 Members boundary load condition Strain Results for Al-7075

5.5 Members boundary load conditions Safety factor Results for Al-7075

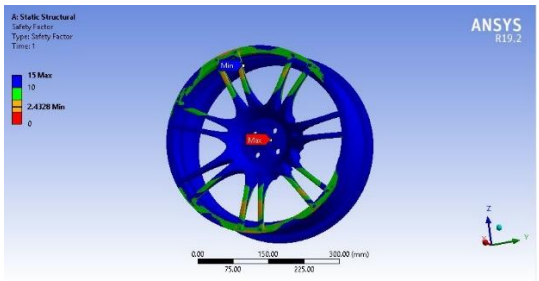

Fig: 5.5 3 Members boundary load condition Safety factor Results for Al-7075

5.6 STRUCTURAL ANALYSIS RESULT'S TABLES

Applying the 3, 5 and 7 members load on wheel rim and taken results at the boundary conditions i.e. Deformation, stress, strain and safety factor

5.7 3 Members boundary load condition

The following table shows deformation, stress, strain, safety factor for 3 members boundary load condition is compared to Al-7075 & Al-7068 materials.

Table 5.1 3 Members boundary load condition

3 members	Al-7075	Al-7068
Deformation (mm)	1.1461	1.1232
Stress (Mpa)	174.69	174.53
Strain	0.0024333	0.0023828
Safety factor	2.4328	2.7503

5.8 5 Members boundary load condition

The following table shows deformation, stress, strain, safety factor for 5 members boundary load condition is compared to Al-7075 & Al-7068 materials.

Table 5.2 5 Members boundary load condition

5 members	Al-7075	Al-7068
Deformation (mm)	1.2432	1.2184
Stress (Mpa)	189.32	189.16
Strain	0.002637	0.0025825
Safety factor	2.2449	2.5376

5.9 7 Members boundary load condition

The following table shows deformation, stress, strain, safety factor for 3 members boundary load condition is compared to Al-7075 & Al-7068 materials.

Table 5.3 7 Members boundary load condition

7 members	Al-7075	Al-7068
Deformation (mm)	1.3403	1.3135
Stress (Mpa)	203.96	203.81
Strain	0.0028409	0.0027825
Safety factor	2.0838	2.3552

- In 3 members boundary load condition Al-7075 material is Deformation is 1.1461 mm, Stress is 174.69 Mpa, Strain is 0.002433, Safety factor is 2.4328 and for Al-7068 material is Deformation is 1.1232 mm, Stress is 174.53 Mpa, Strain is 0.0023828, Safety factor is 2.7503.
- In 5 members boundary load condition Al-7075 material is Deformation is 1.2432 mm, Stress is 189.32 Mpa, Strain is 0.002637, Safety factor is 2.2449 and for Al-7068 material is Deformation is 1.2184 mm, Stress is 189.16 Mpa, Strain is 0.0025825, Safety factor is 2.5376.
- In 7 members boundary load condition Al-7075 material is Deformation is 1.3403 mm, Stress is 203.96 Mpa, Strain is 0.0028409, Safety factor is 2.0838 and for Al-7068 material is Deformation is 1.3135 mm, Stress is 203.81 Mpa, Strain is 0.0027825, Safety factor is 2.3552.

It is observed that the Deformation, Stress and Strain values are less for Al-7068 when compared to Al-7075 material with high in Safety factor

6.0 DYNAMIC ANALYSIS RESULTS

6.1 Boundary conditions

In dynamic analysis, natural frequency results calculated with the help of self-weight of the object. A sound wave is created as a result of a vibrating object. The vibrating object is the source of the disturbance that moves through the medium

The natural frequency is important for many reasons:

1 All things in the universe have a natural frequency, and many things have more than one

2 An object's natural frequency, you know how it will vibrate.

3 An object vibrates, you know what kinds of waves it will create.

4 In specific kinds of waves, you need to create objects with natural frequencies that match the waves you want.

6.2 Degrees of freedom

An object is space has six degrees of freedom. In those three degrees are translation and another three are rotation.

- Translation – movement along X, Y and Z-axis.
- Rotation – rotate about X, Y and Z-axis.

Here wheel studs fixed at center and then selected modes 6 and then solving each mode natural frequency value results and the results shown in below. The tests are conducted at 6 modes i.e.

Mode 1 ---- Translation on X-axis

Mode 2 ---- Translation on Y-axis

Mode 3 ---- Translation on Z-axis

Mode 4 ---- Rotation on X-axis

Mode 5 ---- Rotation on Y-axis

Mode 6 ---- Rotation on Z axis

6.3 Wheel studs fixed at center plain axis

Fig: 6.1 Wheel studs fixed at center plain axis

6.3 Table Natural frequency value on six degrees of freedom

The following table shows the Natural frequency Al-7075 and Al-7068 materials obtain value.

Table 6.1 Natural frequency value on six degrees of freedom

	Al-7075	**Al-7068**
Mode1 (hz)	294.96	304.21
Mode2 (hz)	341.38	352.06
Mode3 (hz)	342.15	352.88
Mode4 (hz)	349.65	360.01
Mode5 (hz)	353.29	363.59
Mode6 (hz)	485.01	499.84

7.0 CONCLUSION

In this work Kia carnival prestige vehicle wheel was developed with the help of solid works and then analyzed with structural and dynamic boundary conditions, and also suggested the best a material which can withstand high speed maximum boundary load conditions. Al-7075 and Al-7068 materials were chosen as materials for analysis.

Kia carnival prestige vehicle chosen and analyzed with minimum load to maximum boundary load conditions i.e., 3 to 5 and 7 members' loads.

- In 3 members boundary load condition Al-7075 material is Deformation is 1.1461 mm, Stress is 174.69 Mpa, Strain is 0.002433, Safety factor is 2.4328 and for Al-7068 material is Deformation is 1.1232 mm, Stress is 174.53 Mpa, Strain is 0.0023828, Safety factor is 2.7503.

- In 5 members boundary load condition Al-7075 material is Deformation is 1.2432 mm, Stress is 189.32 Mpa, Strain is 0.002637, Safety factor is 2.2449 and for Al-7068 material is Deformation is 1.2184 mm, Stress is 189.16 Mpa, Strain is 0.0025825, Safety factor is 2.5376.
- In 7 members boundary load condition Al-7075 material is Deformation is 1.3403 mm, Stress is 203.96 Mpa, Strain is 0.0028409, Safety factor is 2.0838 and for Al-7068 material is Deformation is 1.3135 mm, Stress is 203.81 Mpa, Strain is 0.0027825, Safety factor is 2.3552.
- In Mode 1 i.e. Translation on X axis, The Natural frequency is observed for Al- 7075 is 294.96 and Al 7068 is 304.21.
- In Mode 2 i.e. Translation on Y axis, The Natural frequency is observed for Al- 7075 is 341.38 and Al 7068 is 352.06.
- In Mode 3 i.e. Translation on Z axis, The Natural frequency is observed for Al- 7075 is 342.15 and Al 7068 is 352.88.
- In Mode 4 i.e. Rotation on X axis, The Natural frequency is observed for Al- 7075 is 349.65 and Al 7068 is 360.01.
- In Mode 5 i.e. Rotation on Y axis, The Natural frequency is observed for Al- 7075 is 353.29 and Al 7068 is 363.59.
- In Mode 6 i.e. Rotation on Z axis, The Natural frequency is observed for Al- 7075 is 485.01 and Al 7068 is 499.84

From result analysis it is observed that Al-7068 material is suitable for both conditions like structural and dynamic, and it has strength to weight ratio values, and also less in weight compare to Al-7075 material. This Al-7068 has very good natural frequency range values, and which withstand more vibrations than Al-7075, and also Al-7068 material has high safety factor values with least stress values, and this can increase the vehicle performance in terms of less fuel consumption due to less in weight and also increase the durability of the object. Finally it is concluded that Al-7068 material is best when compared to Al-7075 material.

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