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Comprehensive analysis and comparison of the structural properties of aluminium alloy wheels

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ABSTRACT

This paper is an research study about the comprehensive analysis of the structural properties of aluminium alloy wheels commonly used in the automotive industry. Finite element analysis was performed to simulate the behaviour of the wheels under the different load conditions, taking into account the geometry. Some of the basic materials are selected as widely used in the industry like AA 6061-T6, AA 6082-T6, AA 7075-T6 and AA 6063-T835. The results of the analysis show that the wheels are capable of withstanding the stresses and strains imposed on them during normal operation are compared with the other material structural results. By this approach the best aluminium alloy material AA 7075-T6 is selected hence the deflection under the condition of load is very less. Further the structural deformation for the best material is studied for the change in design of the aluminium wheel to overcome the structural deformation. An triangular ribs are used to resist the deformation by increasing the strength.

Keywords – *Aluminium alloy wheels, Material properties, Design Parameters, Analysis results.*

1. INTRODUCTION

Aluminium alloy wheels have become increasingly popular in the automotive industry due to their lightweight, high strength, and corrosion resistance[1]. However, the structural integrity of these wheels is crucial for their safe and reliable performance on the road. Structural analysis of aluminium alloy wheels is therefore essential to ensure their design and manufacturing meet the necessary standards and regulations[10]. In recent years, the use of finite element analysis (FEA) has become a common approach for investigating the structural behaviour of aluminium alloy wheels[8]. FEA allows for the simulation of complex geometries and loading conditions, providing valuable insights into the stresses and strains experienced by the wheels in different situations.

This type of analysis involves creating a virtual model of the wheel and applying simulated loads to the model to calculate the resulting stresses and strains. The accuracy of the simulation depends on the accuracy of the input data, such as material properties, geometry, and manufacturing processes. Therefore, it is essential to ensure that the input data is carefully chosen and validated to obtain accurate results. In this context, this study aims to perform a structural analysis of aluminium alloy wheels using finite element analysis. The study will investigate the behaviour of the wheels under different loading conditions, with a focus on identifying potential failure modes and areas of stress concentration. The results of this analysis can provide valuable information for improving the design and manufacturing processes of aluminium alloy wheels, ultimately leading to safer and more reliable automotive components[6].

Aluminium alloy wheels are typically made from a combination of aluminium and other elements, such as copper, magnesium, silicon, and zinc, which are added to enhance the strength, hardness, and other mechanical properties of the alloy. The specific composition of the alloy depends on the desired properties and the intended application of the wheel. Some of the commonly used aluminium alloys for wheel manufacturing include, AA 6061-T6[4]: This is a high-strength alloy that offers good corrosion resistance and can be easily welded and machined. AA 6082-T6[3]: This alloy offers high strength, good corrosion resistance, and excellent formability. It is often used in the manufacture of wheels for racing and high-performance vehicles. AA 7075-T6[7]: This is a high-strength alloy that offers excellent fatigue resistance and is commonly used in the manufacture of wheels for aerospace and military applications. AA 6063-T835[14]: This is a cast aluminium alloy that offers good ductility and is commonly used in the manufacture of wheels for passenger vehicles.

In addition to these alloys, other materials may also be used in the manufacture of aluminium alloy wheels[2], such as steel or magnesium for the centre hub or brake disc attachment points, or carbon fibre for the outer rim. The choice of materials depends on various factors, including cost, weight, strength, and performance requirements.

2. EXPERIMENTAL PROCEDURES

Seven-spoke aluminium alloy wheels are a popular design option for automotive wheels, offering a stylish and sporty look. These wheels typically feature seven evenly spaced spokes extending from the centre hub to the outer rim of the wheel. The design provides a balance between form and function, with the spokes providing a visual appeal while also offering structural support to the wheel. Manufacturing these wheels involves using specialized machinery to shape the aluminium alloy into the desired shape and size. The process typically involves casting or forging the aluminium alloy, followed by machining to achieve the final shape and surface finish. The spokes are designed to provide strength and stability to the wheel, while the rim is shaped to provide a suitable mounting surface for the tire.

Design of wheel

The design of 7 strokes alloy is done in the Solid works and the final design is shown in the Fig.1

Fig.1 7 spokes alloy wheel

Material properties

Material properties	AA 6061-T6[11]	AA 6082-T6[12]	AA 7075-T6[13]	AA 7075-T6[14]
Tensile Strength, Ultimate	290 Mpa	290 Mpa	572 Mpa	330 Mpa
Tensile Strength, Yield	255 Mpa	350 Mpa	503 Mpa	295 Mpa
Elongation at Break	12%	10%	9%	8%
Modulus of Elasticity	68.9 Gpa	65 Gpa	71.7 Gpa	69 Gpa
Shear Strength	186 Mpa	180 Mpa	331 Mpa	205 Mpa

Load conditions and calculations

1. Self weight on single wheel (W)

Assuming the car is a normal passenger car = 1.5 tons =1500 kg

Assuming the driver weight = 80 kg

In the case of front engine with rear wheel drive the 60% of the load is shared by the front two wheels hence, the single wheel load is calculated by,

$$W = (1500*0.6) / 2$$ [21]

$$\underline{W = 530 \text{ kg}}$$

2. Shear stress acting on the wheel (τ)
Assuming the speed of the car = 80 kmph = 22.22 m/s
The velocity of the car is arrived by the speed of the car,

- $V = (2\pi N) / 60$ [21]
  $22.22 = (2\pi N) / 60$
  $N = 139.61$ rpm
- $P = 2\pi NT / 60$ [21]

Where as,
Horse power of the car is taken as 180 hp
The power of the car engine is = 134.226 kw

$$134.226 = (2\pi*139.61)*T /60$$

$$\underline{T = 9181.03 \text{ N-m}}$$

- $T = \pi/16 * d^3 * \tau$ [21]

Where as the diameter is taken as 65 mm

$$9181.03*10^3 = \pi/16 * (65)^3 * \tau$$

$$\tau = 170.26 \text{ N/mm}^2$$

3. Impact load (F)

$$F = m*v / t^2$$ [21]

The time taken is m/s so the time is 1 sec

$$F = (1580 * 22.22) / (1)^2$$

$$\underline{F = 35107.6 \text{ N}}$$

3. RESULTS AND DISCUSSION

AA 6061-T6 – material behaviour

The structural analysis of AA 6061-T6 – material behaviour is studied in Ansys 2021 R2 version. All the load conditions are given to the alloy wheel, triangular with coarse mesh type is given to the alloy wheel with is material property. Hence the deflection of the material AA 6061-T6 is 3.2572 mm. The deflection of the AA 6061-T6 material is given in Fig.3.1.

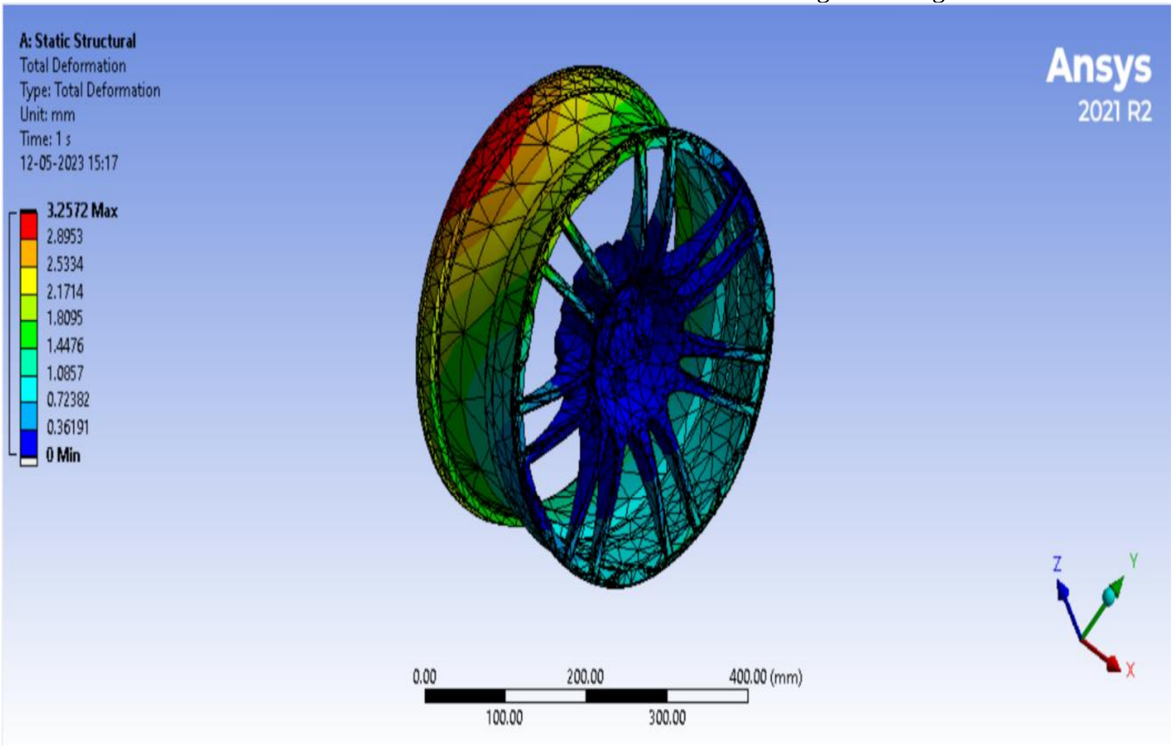

Fig.3.1. AA 6061-T6 – material behaviour

AA 6082-T6 – material behaviour

The structural analysis of AA 6082-T6 – material behaviour is studied in Ansys 2021 R2 version. All the load conditions are given to the alloy wheel, triangular with coarse mesh type is given to the alloy wheel with is material property. Hence the deflection of the material AA 6082-T6 is 6.5143 mm. The deflection of the AA 6082-T6 material is given in Fig.3.2.

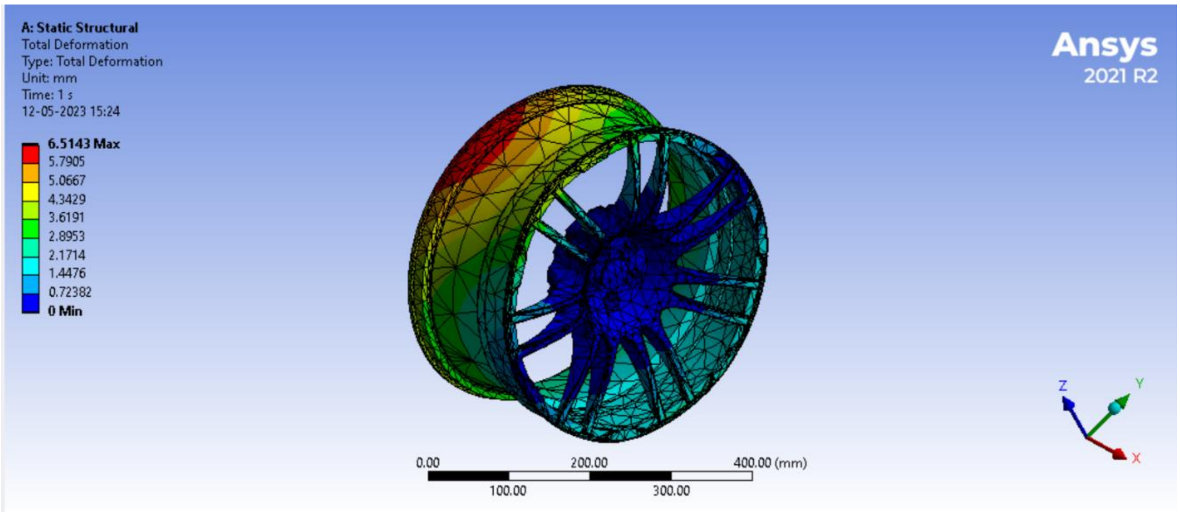

Fig.3.2. AA 6082-T6 – material behaviour

AA 7075-T6 – material behaviour

The structural analysis of AA 7075-T6 – material behaviour is studied in Ansys 2021 R2 version. All the load conditions are given to the alloy wheel, triangular with coarse mesh type is given to the alloy wheel with is material property. Hence the deflection of the material AA 7075-T6 is 1.6286 mm. The deflection of the AA 7075-T6 material is given in Fig.3.3.

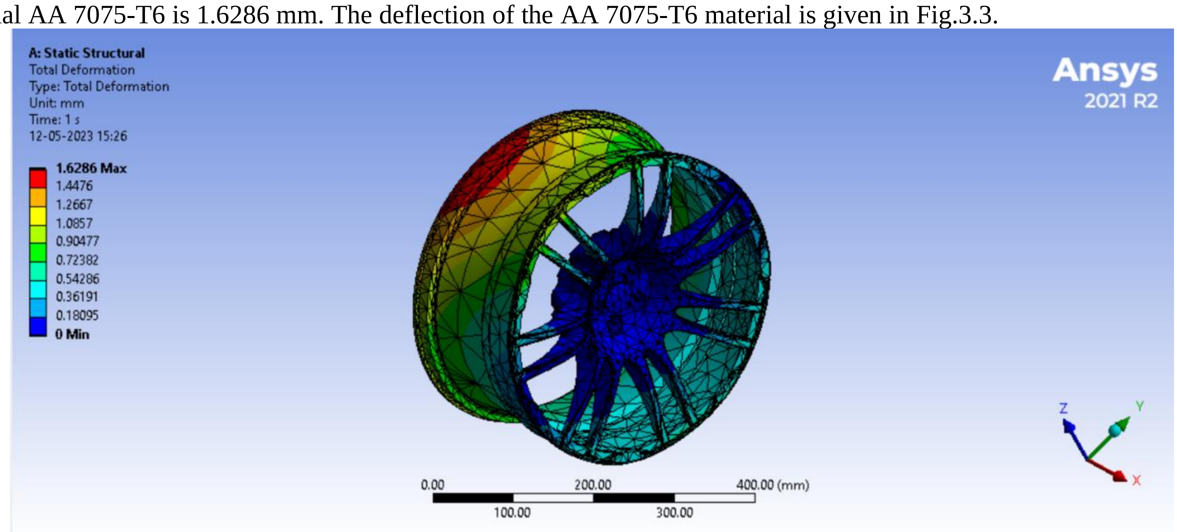

Fig.3.3. AA 7075-T6 – material behaviour

AA 6063-T835 – material behaviour

The structural analysis of AA 6063-T835 – material behaviour is studied in Ansys 2021 R2 version. All the load conditions are given to the alloy wheel, triangular with coarse mesh type is given to the alloy wheel with is material property. Hence the deflection of the material AA 6063-T835 is 4.8858 mm. The deflection of the AA 6063-T835 material is given in Fig.3.4.

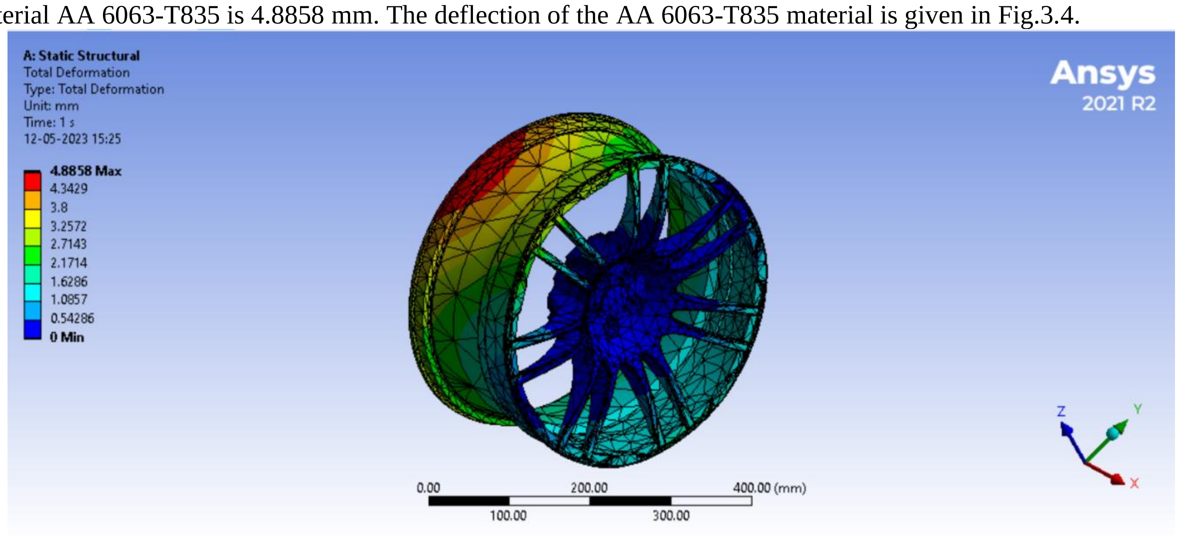

Fig.3.4. AA 6063-T835 – material behaviour

Results

Material	Deflection
AA 6061-T6	3.2572 mm
AA 6082-T6	6.5143 mm
AA 7075-T6	1.6286 mm
AA 6063-T835	4.8858 mm

Inference

Hence after giving all the load conditions to all the various material, the various deflection is observed in the millimetre. The less deflection in the material is AA 7075-T6 - 1.6286 mm, So AA 7075-T6 material alloy wheel can be modified. The modification that done to increase the strength in order to reduce the deflection is by giving the ribs to the design. The modified alloy wheel is shown in Fig.3.5.

Modified alloy wheel design

Fig.3.5. 7 spokes alloy wheel with ribs

Structural analysis

The structural analysis of AA 7075-T6 with ribs is studied in Ansys 2021 R2 version. All the load conditions are given to the alloy wheel, triangular with coarse mesh type is given to the alloy wheel with is material property. Hence the deflection of the material AA 7075-T6 with ribs is 0.67811 mm. The deflection of the material AA 7075-T6 with ribs is given in Fig.3.6.

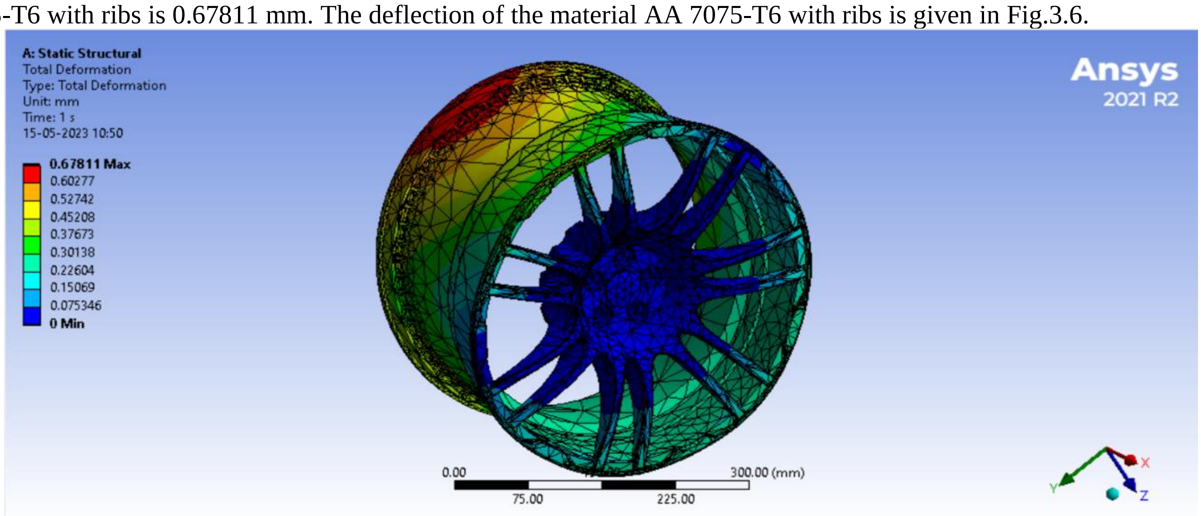

Fig.3.6. Structural analysis of AA 7075-T6 with ribs

4. CONCLUSION

The structural analysis of aluminium alloy wheels is essential to ensure their safety, durability, and performance. The design and manufacturing of aluminium alloy wheels require careful consideration of various factors such as material properties, geometry, load conditions, and manufacturing processes. Finite element analysis (FEA) is a useful tool for predicting the behaviour of the wheel under different loading conditions and optimizing the design to improve performance and reduce weight. AA 7075-T6 is a popular material choice for manufacturing aluminium alloy wheels due to its high strength, good corrosion resistance, and easy machinability. However, the deflection of the material AA 7075-T6 is 1.6286 mm. Hence, Seven-spoke aluminium alloy wheels are a popular design option for automotive wheels, offering a balance between form and function. Overall, the structural analysis of aluminium alloy wheels plays a crucial role in ensuring the safety and performance of passenger vehicles. By modifying the alloy wheel with ribs in the material AA 7075-T6 the deflection is observed as 0.67811 mm. Advances in materials, manufacturing processes, and analytical tools are continuously improving the design and performance of aluminium alloy wheels, and this trend is expected to continue in the future.

REFERENCES

[1]. Naim1, R Kumar1 and S Bhatia1 - A review paper on materials used for manufacturing of alloy wheels. (2006)
[2]. K. Lakshmi Chaitanya*, Kolla Srinivas - A Review on Use of LM Based Aluminium Alloys in Automobile Components. (2018)
[3]. Aleksander Karolczuk, Marta Kurek, Tadeusz Łagoda - Fatigue life of aluminium alloy 6082 t6 under constant and variable amplitude bending with torsion. (2015)
[4]. Davoud mashhadi jafarlou - Evaluation of the Mechanical Properties of AA 6063 Processed by Severe Plastic Deformation. (2015)
[5]. Xintao Cui1* - Mechanical properties of aluminium alloy 6082-T6 plate and butt weld joint: Experimental test, numerical modelling and application. (2022)
[6]. Andrea Battiato, Abdallah Alaoui & Etienne Diserens - Impact of Normal and Shear Stresses Due to Wheel Slip on Hydrological Properties of an Agricultural Clay Loam: Experimental and New Computerized Approach. (2014)
[7]. Peter Totaro a,b, Boris Khusid a,* - Multistep anodization of 7075 – T6 aluminum alloy.(2021)
[8]. K. Srinivasa Rao, M .Rajesh, G.Sreedhara Babu - Design and analysis of alloy wheels. (2017)
[9]. S. Ajmal Hussain1, Rajaneesh R2, Hashim Nizam3, Jithin K4 - Experimental analysis on aluminum alloy (6063) with silicon carbide: an experimental investigation. (2019)
[10]. Madhusudhan R, Dr. B. Sadashive Gowda - Modeling and analysis of aluminium alloy automotive wheel rim. (2020)
[11]. Material data from the matt web for AA 6061-T6 - MaterialData_9388.
[12]. Material data from the matt web for AA 6063-T835 - MaterialData_9404.
[13]. Material data from the matt web for AA 7075-T6 - MaterialData_9595.
[14]. Material data from the matt web for AA 6082-T6 - MaterialData_9432.
[15]. Liu Cheng, Ren Nianzu, Yang Qingsong, Chen Chao, Tian Cheng, Liu Zhengguo - Stress State Measurement and Result Analysis of Car Wheels China Automotive Technology & Research Center Co.Ltd, Tianjing, 300300. (2019)
[16]. George Hawkins & Dr. Vikas Kumar - Structural Analysis of Alloy Wheels. 1478 (2020) 012007
[17]. Gaurav Machave*, Pote Susheel Sambhaji, Prof. R.A.Kathar - Study of influence of pressure and load on wheel rim by radial fatigue test.(2015)
[18]. K. Periasamy*, M. Jayaraman, S. Rajkumar - Mechanical properties of 7075-t6 aluminium alloy surface hybrid composites synthesised by friction stir processing. (2019)
[19]. Sourav Das, (CAE Analyst) - Design and Weight Optimization of Aluminium Alloy Wheel - Altair Engineering India Pvt Ltd, Bangalore.(2014)
[20]. Brandon J Van Dyk, J Riley Edwards, Marcus S Dersch, Conrad J Ruppert Jr and Christopher PL Barkan - Evaluation of dynamic and impact wheel load factors and their application in design processes. (2016)
[21]. R.S. Kurmi - A Textbook of Machine Design - S. Chand Publishing, (2005)

