STATIC ANALYSIS OF FOUR-WHEELER ALLOY WHEEL USING ANSYS WORKBENCH

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ABSTRACT: The motor bike wheels play a significant role in holding the load. Spokes typically experience loading and strain. Therefore, the wheel 's reaction under fatigue loads needs to be tested. We studied 90-degree impact test simulation for cast aluminium alloy, carbon steel, magnesium alloy and stainless-steel wheel using 3D basic finite element analysis in the present work Volume of wheel spokes was modelled and tested for loading and pressure using finite element simulation programme ANSYS workbench. Alloy wheel model built 6 spokes, 8 spokes and 10 alloy wheel spokes in variety of spokes I.e. Modelling of four separate wheel rim configurations using solid job software and testing using ANSYS15.0 with standard number of spokes along with striker was carried out. Study findings are presented as a function of time, and the accumulated effect of Von Mises' relative stress on the wheel rim is calculated and compared with each form.

KEYWORDS: Alloy wheel, Finite Element Analysis, Stress, Deflection, Structural Steel (SS), Aluminium (Al), Magnesium (Mg), Stainless Steel (CS) Ansys.

I. INTRODUCTION

Because of the versatility an automotive wheel is a very necessary feature of cars. In addition, the wheel is perhaps one of the most critical aspects of a vehicle when discussing safety. Because of these reasons, the wheel construction validation process has difficult qualifications. The nature of the wheel must not only fulfil these requirements but also be artistic and economical. After sample output, there are some disruptive mechanical tests conducted to verify the wheel size. These include I spinning bending tests, (ii) testing for radial fatigue and (iii) testing for impact. Both of these disruptive mechanical experiments are conducted on the basis of the original or updated configuration following development of the mould and sample. If the wheel fails to pass the tests, the design assessment process restarts to change the wheel 's shape, with modifications to the mould involved. The car wheels of the decade emerged from early articulated types of wood and steel. Today's rims in new cars are moved from automotive and bicycle manufacturing to flat steel discs and eventually to pressed metal structures to advanced casting to forged aluminium. Extremely promising inventions join after years of testing and extensive field trials. Since the 1970s, numerous innovative testing methods and well-helped computational stress assessments have been applied. In recent years the procedures have been improved by a number of computational and practical approaches for structural analysis (strain gauge and finite-element approaches). Over the past 10 years, endurance analysis (prediction of fatigue period) and durability approaches have been applied to the car wheel for treating differences in engineering structure. The wheel weight has always been considerable. Thus, a number of lightweight centre sections were specially engineered or organised to allow transmission of vertical as well as axial and tangential forces from the tyre to the axle. The construction of rims led to the use of steel profiles with thickness differences to be achieved during rim manufacturing to allow a homogeneous distribution of stress and a lighter wheel. Meanwhile, with new materials such as aluminium and magnesium or their variations, completely new manufacturing processes for casting and forging have been increasingly adapted. There are currently the most varied varieties of materials and technical solutions possible, allowing for the optimal degree of practical performance, weight and expense. Wheel styles vary with the processing processes, material and intended purpose. The major types are steel disc wheels, cast light iron, and forged wheels according to material and manufacturing methods. The rim profile and disc shape of the wheel can differ based on vehicle type such as passenger cars, commercial vehicles, agricultural tractors, cycles and motorcycles.

Figure 1: Alloy wheel with Tyre

II. ROLES OF AN ALLOY WHEEL

A tyre rim in its fundamental nature is a transition feature between the tyre and the car. The key roles of a tyre surface are as follows:

- Torque transfer (braking and acceleration).
- Mass support (supporting motor vehicle weight).
- Adds mass (damping mass for comfort driving).
- Heat discharges (from the braking).
- Value Adds.
- Bears damage (hazards to the roads).
- Conserves energy (power potential at momentum).

III. FINITE ELEMENT ANALYSIS

The ANSYS software helps engineers create computational models or transfer CAD models of structures, objects, materials or procedures, add loads or other requirements of design efficiency, and analyse physical responses such as stress thresholds, temperature distribution or magnetic field effects of vectors. In certain cases concept creation is inappropriate or impractical. The ANSYS package was used in many instances of this kind, including biomechanical applications such as intraocular contact lenses. These specific applications range from pieces of heavy machinery to an integrated circuit board, to the bit-keeping mechanism of a continuous coal-mining plant. ANSYS design optimization lets engineers minimise the number of costly designs, adjust rigidity and reliability to meet goals and determine the right geometric equilibrium modifications. Competitive companies explore ways to produce products of the highest quality at the lowest possible cost. ANSYS (FEA) can benefit significantly from reducing manufacturing and development costs, and by giving engineers more trust in the goods they make. Owing to loads which do not require major friction and damping effects, static analysis is used to assess the displacements, stresses, strains and pressures in structures or materials. It is presumed that steady charging takes place under conditions of reaction. Forms of charging that can be integrated into a static study include externally applied forces and stresses, stable state inertial forces such as gravity or forced displacement (non-zero), temperatures (for thermal stress).

IV. MODELLING OF ALLOY WHEEL

This the most complex three-dimensional geometric simulation. This usually uses solid geometry forms to create the model, called image. Colour graphics quality is another feature of Solid Work framework. By way of colour, more detail can be shown on the graphics screen coloured icons to better illustrate components when assembling or highlighting measurements or a host of other purposes.

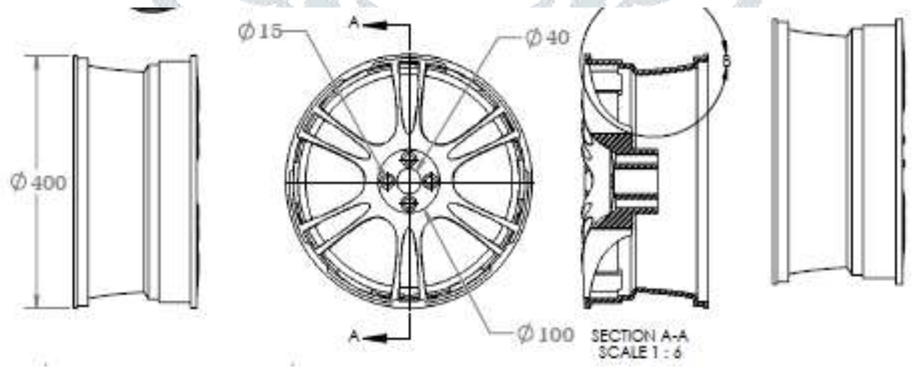


Figure 2: Dimension of Alloy wheel in solid work

V. ANALYSING THE MODEL IN ANSYS

If the concept for Solid Work is produced, the. IGS FILE is compiled in IGES format. In this configuration the architecture can be supported by the ANSYS programme. After the concept is imported into ANSYS the analytical process begins. This alloy wheel renders the specifications and processes specified in the design.

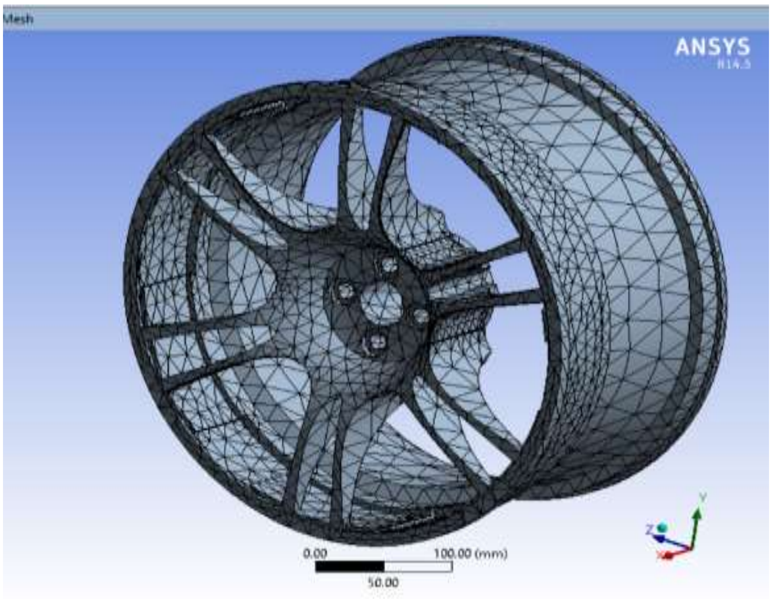


Figure 3: Meshing of Alloy wheel in Ansys

Mathematically, the model of the Alloy wheel to be studied is subdivided into a grid of simple-form finite sized components. Inside each variable the displacement difference is supposed to be determined by basic functions of polynomial profile and nodal movements. Equations are produced for the strains and stresses in terms of unspecified nodal deflections. From this, equilibrium equations are built in a matrix form that can be programmed quickly.

VI. BOUNDARY CONDITIONS FOR ANALYSIS OF ALLOY WHEEL USING ANSYS

After design the model then Alloy wheel in Ansys is meshed, we need to apply the suitable boundary condition under which the thermal Analysis will be completed.
Figure 4, represent the applied boundary conditions on Alloy wheel has been kept fixed while centre hub on the outer surface of the Alloy wheel pressure has been applied, to optimize failure of Alloy wheel.

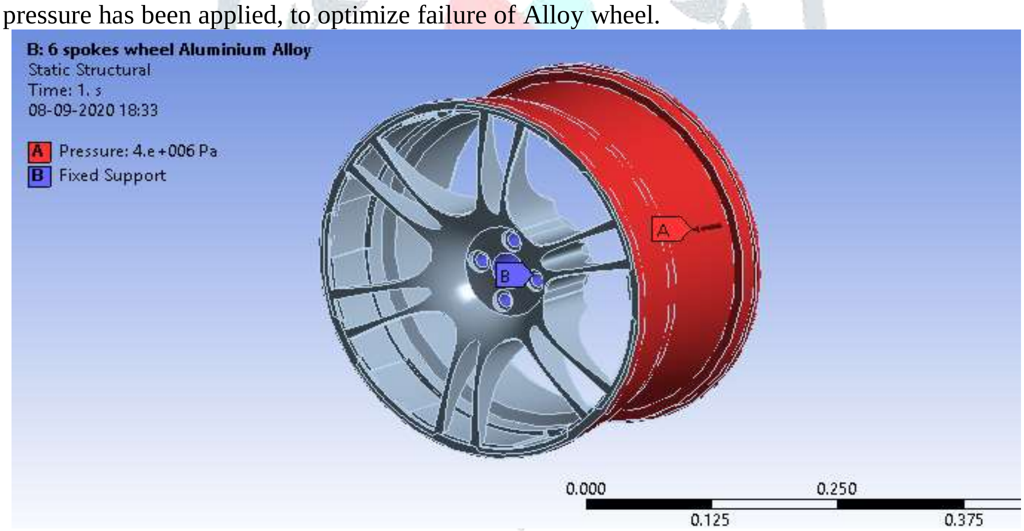


Figure 4: Alloy wheel with boundary conditions

VII. MATERIAL PROPERTIES USED FOR MODEL

Structural steel, magnesium alloy, aluminium alloy and Carbon steel considered as material in present study. Two types of material design of Alloy wheel used in this study Properties of material are described below.

Table 1: Material Properties for Alloy wheel

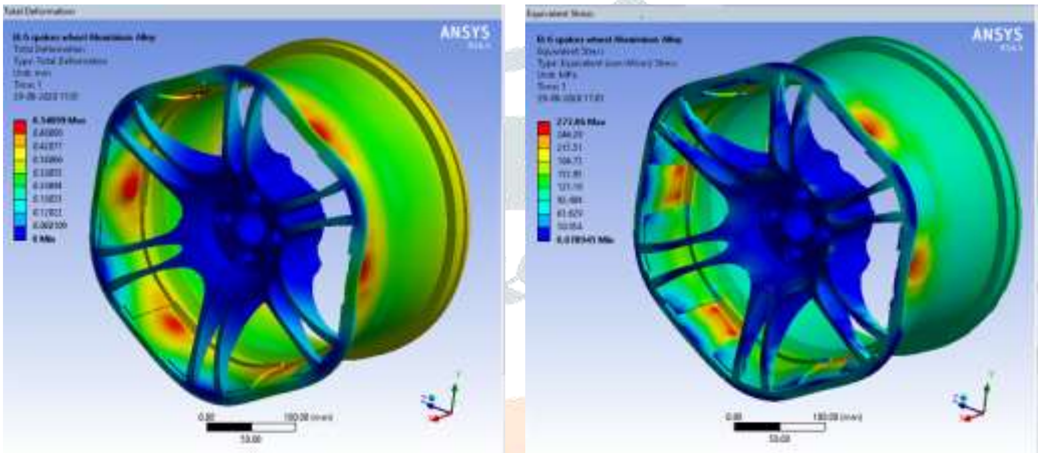
Material Properties	Structural Steel	Aluminium (Al 360)	Magnesium Alloy	Carbon steel
Density	7850kg/m^3	2630Kg/m3	1810	7858
Poisson ratio	0.29	0.33	0.35	0.35
young's modulus	20 GPa	26 GPa	42 GPa	22 GPa
tensile ultimate strength	460 MPa	317 MPa	230	425 MPa
tensile yield strength	250 MPa	170 MPa	160 MPa	282 MPa

VIII. RESULTS AND DISCUSSION

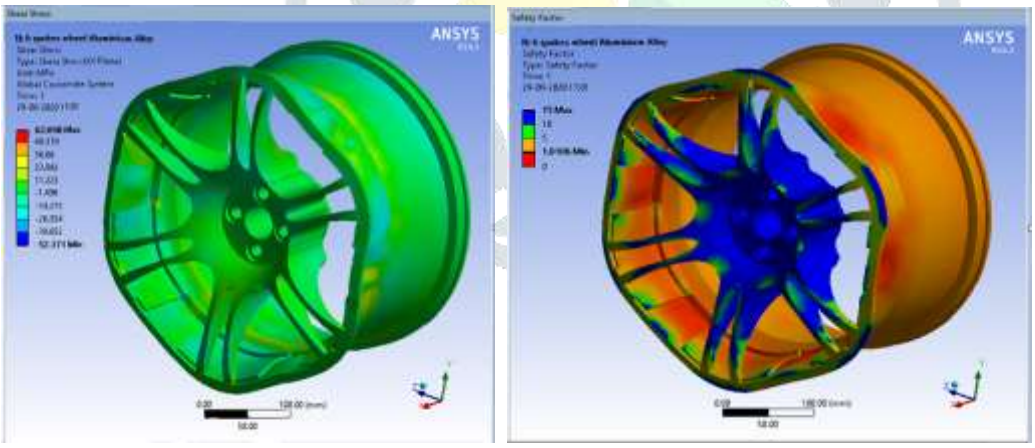
The various boundary conditions and Pressure is imposed on the FEA model of Alloy wheel, structural behaviour can be obtained. Static analysis also performed to find out stress and deflection in alloy wheel. There are four different material of alloy wheel used to designed by using Solid work i.e. Aluminium alloy and structural steel, magnesium alloy and Carbon steel materials used for alloy wheel static analysis in ANSYS by assigning the Material properties of model. static analysis is a collection of methods in which the deviation of a physical property of a material is calculated as a function of failure due to loading. The most commonly used methods are those which calculate changes of mass or changes in energy of a model of a material. After processing solution, the contours of Total stress, deflection and Equivalent Stress in Static structural analysis are plotted. These results as part of structural analysis are obtained for all material selected for study to optimize failure of alloy wheel during process.

- **Static analysis of Alloy Wheel Models**

  Failure analysis of alloy wheel is used to determine deflection and other structural quantities that change over time with respect to applied load. The study of deflection and load distribution over time is important in many applications such as in vehicle strength analysis for its deigning. Also, of interest are the load distribution results in developed high stresses and deformation that can cause the failure. Four types of Alloy wheel model designed for each material. Alloy wheel model designed with three types of wheel spokes i.e. 6 spokes, 8 spokes and 10 spokes to optimize its behaviour during loading conditions.

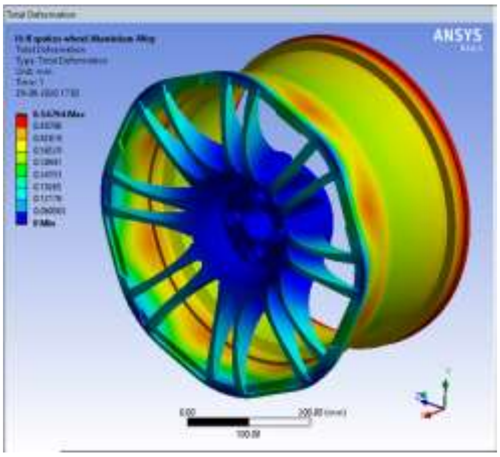


(a) Total deformation of wheel with 6 spokes (b) Equivalent stress of wheel with 6 spokes

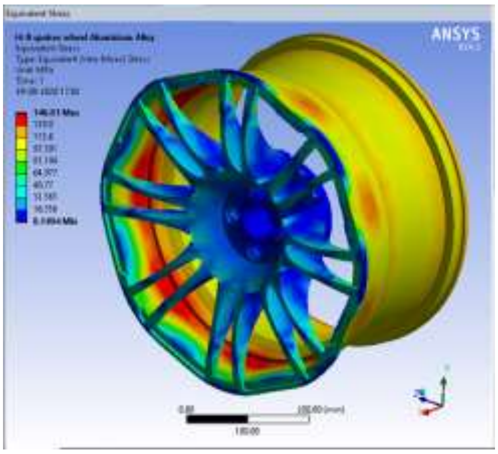


(c)Shear Stress of wheel with 6 spokes (d) Factor of Safety of wheel with 6 spokes

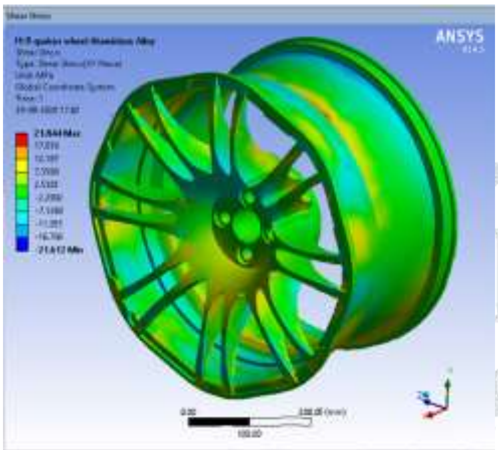
Figure 5: Alloy wheel of Aluminium Alloy with 6 Spokes



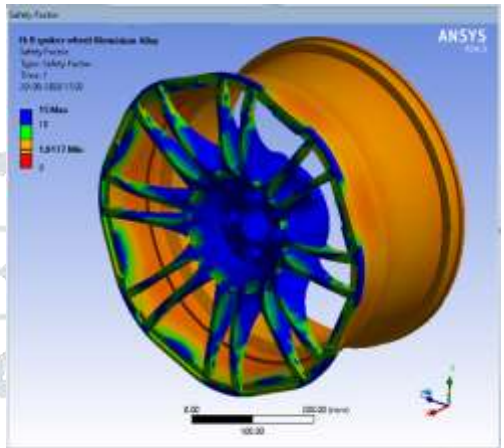
(a) Total deformation of wheel with 8 spokes



(b) Equivalent stress of wheel with 8 spokes

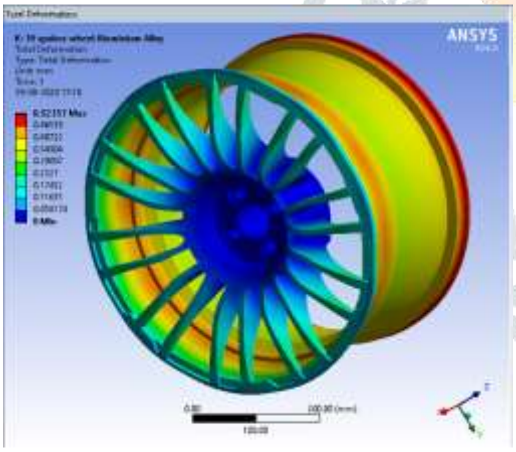


(c)Shear Stress of wheel with 8 spokes

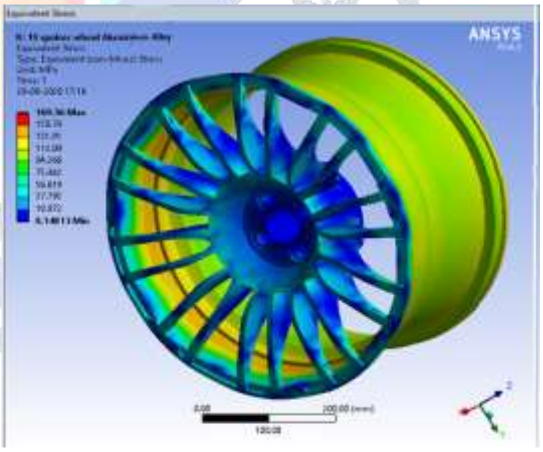


(d) Factor of Safety of wheel with 8 spokes

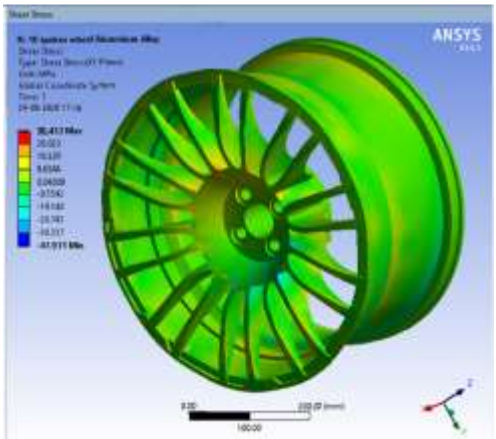
Figure 5: Alloy wheel of Aluminium Alloy with 8 Spokes



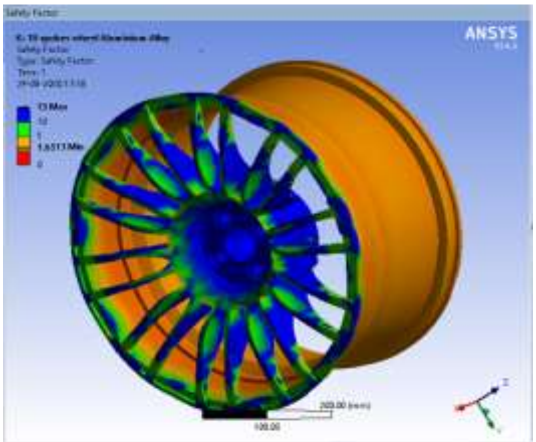
(a) Total deformation of wheel with 10 spokes



(b) Equivalent stress of wheel with 10 spokes



(c)Shear Stress of wheel with 10 spokes



(d) Factor of Safety of wheel with 10 spokes

Figure 5: Alloy wheel of Aluminium Alloy with 10 Spokes

Table 2: structural behaviour of Alloy wheel with Structural Steel material

Structural Steel Alloy Wheel			
Results	**6 Spokes wheel**	**8 Spokes wheel**	**10 Spokes wheel**
Max Stress	172.62	147.51	169.79
Shear Stress	44.64	21.69	38.44
Deformation	0.201	0.192	0.184
Safety Factor	1.44	1.69	1.47

Table 3: structural behaviour of Alloy wheel with Carbon steel material

Carbon Steel Alloy Wheel			
Results	**6 Spokes wheel**	**8 Spokes wheel**	**10 Spokes wheel**
Max Stress	280.8	148.04	166.83
Shear Stress	63.2	21.65	38.52
Deformation	0.188	0.187	0.179
Safety Factor	1	1.9	1.69

Table 4: structural behaviour of Alloy wheel with Aluminium Alloy material

Aluminium Alloy Wheel			
Results	**6 Spokes wheel**	**8 Spokes wheel**	**10 Spokes wheel**
Max Stress	277.26	146.01	169.56
Shear Stress	62.09	21.84	38.41
Deformation	0.54	0.547	0.523
Safety Factor	1.01	1.91	1.65

Table 5: structural behaviour of Alloy wheel with Magnesium Alloy material

Magnesium Alloy Wheel			
Results	**6 Spokes wheel**	**8 Spokes wheel**	**10 Spokes wheel**
Max Stress	274.32	144.82	173.67
Shear Stress	61.67	21.99	38.2
Deformation	0.851	0.869	0.829
Safety Factor	0.7	1.33	1.11

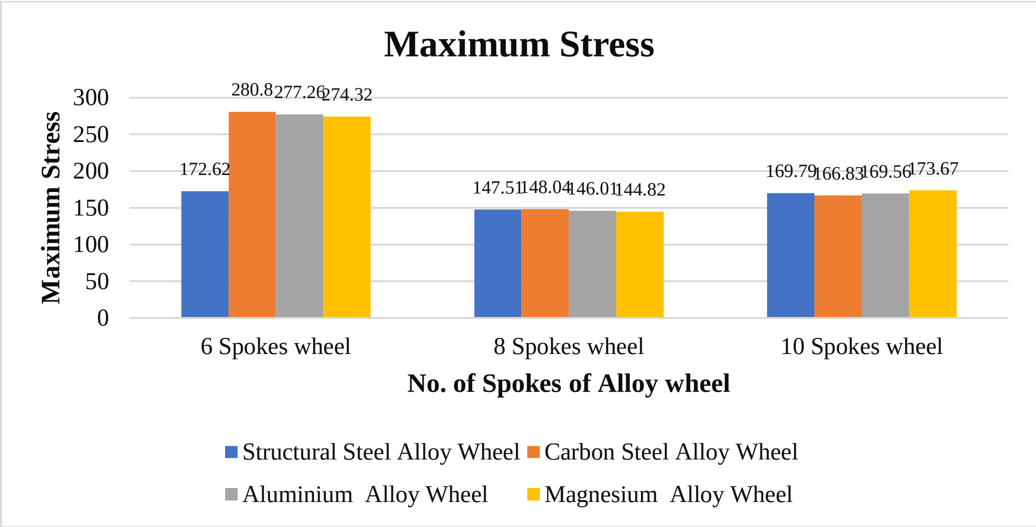


Figure 6: Comparison of Maximum Stress

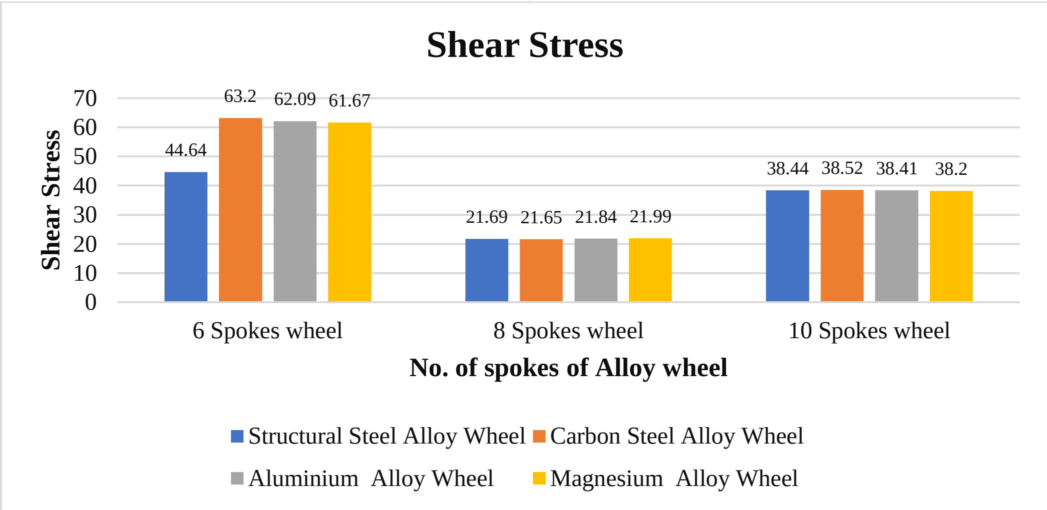


Figure 7: Comparison of Shear Stress

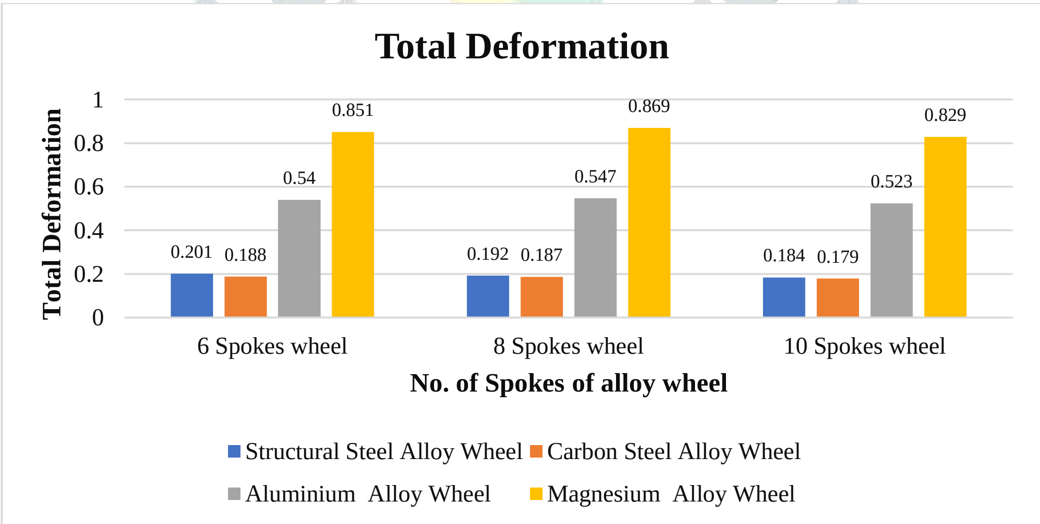


Figure 8: Comparison of Total Deformation

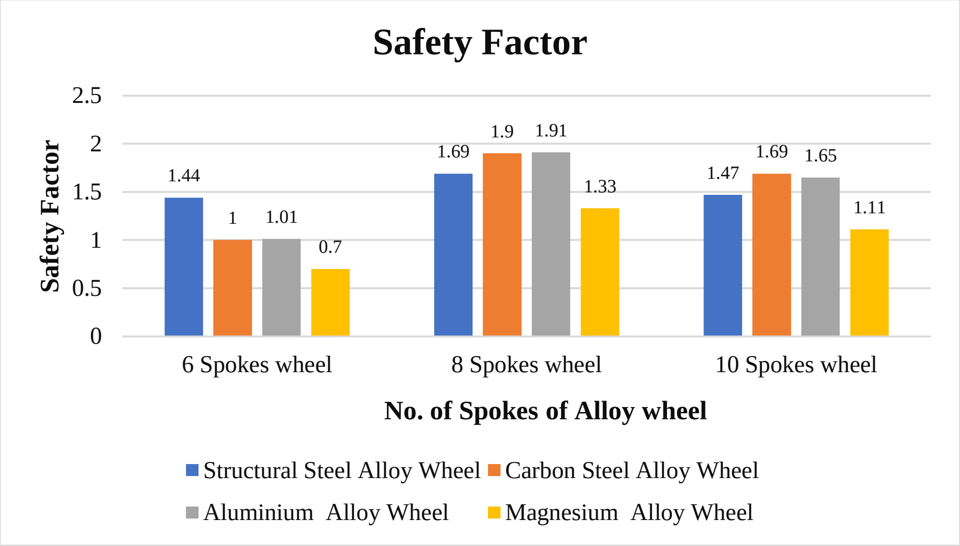


Figure 9: Comparison of Safety Factor

IX. CONCLUSION

This paper deals with the construction of aluminium alloy, carbon steel, magnesium alloy and stainless steel wheel for automotive use, and pays particular attention to minimising wheel failures.

- It can be concluded that, Maximum Stress found at 6 spokes wheel in all material but aluminium alloy show less stress remaining to all.
- Alloy wheel with 8 spokes shows minimum level of maximum stress as comparison to 6 spokes and 10 spokes wheel.
- Maximum shear stress found at alloy wheel with 6 spokes and minimum shear stress found at alloy wheel with 8 spokes, it shows that alloy
- wheel with 8 spokes having better stability.
- Total deformation found minimum structural steel and carbon steel material; maximum deformation found on Magnesium alloy which is higher to all material wheel.
- Safety factor of alloy wheel found maximum at 8 spokes wheel of aluminium alloy material and minimum safety factor found at 6 spokes wheel.

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