DESIGN AND ANALYSIS OF MOTORCYCLE LIGHT WEIGHT ALLOY WHEEL

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Abstract : In recent day's many areas of industry, it is compulsory to draw geometric models of existing objects for which no such model is available. The design and analysis of new effective lighter alloy wheel similar to the real design. Alloy wheels are bike wheels which are made from Different types of alloy of aluminium, magnesium, Titanium metals or sometimes a mixture of them. By reducing the weight of the alloy wheels, it reduces the handling difficulty and reduces the fuel consumption. In a present situations, the design of wheel rim which turns costly solution in industries. So, our target is to reduce the cost of wheel and also Performance optimization is done for strength point of view. In this present work a detailed parametric design of alloy wheel Materials like MG-AZ31B, AL-12%Si, AL5052, AL6061, AL7075 and Ti-5Al-2.5Sn Alloys are used for light weight alloy wheels, For reducing the weight of the alloy wheel, new designs will be created by modifying the cross section of the spoke and reducing the thickness of the hub and varying number of spokes and these results are performed using 3D finite element analysis by changing the geometric parameters to control any possible fail, light weight and for safe stress and deformations, in this present work FE analysis for Bike alloy wheel is carried out for the specific load condition. The new designs are made by using CREO Parametric. Analysis has been done by ANSYS software to determine the various stresses and Deformations of the wheel.

Index Terms **– Bike wheel, MG-AZ31B, AL-12%Si, AL5052, AL6061, AL7075 and Ti-5Al-2.5Sn, CREO Parametric, ANSYS, stress, Deformation.**

I. INTRODUCTION

Alloy wheels are wheels that are made from an alloy of aluminium or magnesium. Alloys are mixtures of metals and other elements. They usually provide strength higher than pure metals, which are usually much softer and more ductile. Alloys of aluminium, magnesium, or Titanium are typically lighter for the similar strength, deliver effective Heat conduction, and often produce better look over steel wheels. Although steel is also an alloy, consisting of iron and carbon, it is the most common material used in wheel production. The term "alloy wheel" is usually reserved for wheels made from non ferrous alloys.

The main desirable feature of alloy wheel is that, it weighs about half of the steel wheel with almost 90% of the strength. Moreover light alloy wheels are excellent conductors of heat which helps the wheel dissipate any heat generated by the tires or the brakes. And greatly reduces the chances of brake failure.

Alloy Wheels are made of alloys of aluminium, magnesium or Titanium. Sometimes it so happens that a mixture of them is used in making alloy wheels.

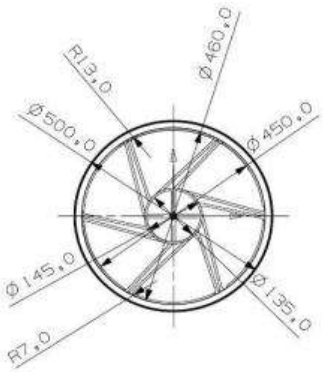
It reduces handling difficulty by reducing unstrung mass, allowing suspension to work in a conjunction with the wheel thus improving grip. Since these wheels are lighter, they help reduce the overall weight of the vehicle reducing fuel consumption slightly.

II. DESIGN AND MODEL ANALYSIS

2.1 Geometric Properties of Alloy Wheel

Here we follow the following dimensions for designing the alloy wheel:

Hub Diameter: 145mm
Hub Thickness: 5mm
Spoke Length: 155mm
Spoke Fillet Radii: 5R at hub
7R and 13R at outer rim
Rim Thickness: 6mm
Rim Outer Diameter: 500mm
Number of Spokes: 6 to 4



2.2 Materials used

Alloys	Density (Kg/m3)	Young's Modulus (MPa)	Compressive Yield Strength (MPa)	Compressive Ultimate Strength (MPa)
Al-7075	2810	71700	203.45	272.53
Al-6061	2712	68948	55.16	124.11
Al-5052	2652	70327	89.632	193.05
Al-12% Si	2657	71016	144.79	296.47
Mg-AZ31B	1771	44816	151.68	255.11
Ti-5Al-2.5Sn	4484	110320	861.84	930.79

2.3 Loads Applied

0 Person Sitting (Load 0) = Weight of Bike (143 vehicle + 20extra kg)
1 Person Sitting (Load 1) = (163 + 65) kg
2 Person Sitting (Load 2) = (163 + 65 x 2) kg
3 Person Sitting (Load 3) = (163 + 65 x 3) kg
4 Person Sitting (Load 4) = (163 + 65 x 4) kg
5 Person Sitting (Load 5) = (163 + 65 x 5) kg

Mass of Bike, Dead Weight of Bike =143 Kgs
Other Loads =20 Kgs
Total Gross Weight=143+20 = 163 Kgs =163x9.81 N
Due to tires and suspension system, the load on the wheel is reduced by 30%.
So the net weight will be multiplied by 0.7 of the total weight.
W_{net} =163x9.81x0.7 N=1119.32N
Reaction force on bike=N_r=1119.32N

Number of Wheels: 2
And also Taking factor of safety=2 from that
Considering total Reaction Force on only one wheel F_T =1119.32N

Rim surface area which is having 6 spokes = 48299.69 mm^2 (this can be obtained from selecting faces on rim by using measuring tool in solid works)

Stress on the each Rim = N/A = 0.02321 N/mm^2
So pressure on the each rim for "0 Person Sitting"= 0.02321 Mpa

It is similarly for different Loads Stress on Each Rim with Loads
Pressure by 0 Person Sitting = 0.0232 Mpa
Pressure by 1 Person Sitting = 0.0324 Mpa
Pressure by 2 Person Sitting = 0.0417 Mpa
Pressure by 3 Person Sitting = 0.0509 Mpa
Pressure by 4 Person Sitting = 0.0601 Mpa
Pressure by 5 Person Sitting = 0.0694 Mpa

2.4 Loads Applied

Here we consider the net weight of the motor cycle is 163kg and the maximum allowable Load 5. The tyre used is a common version with inner tube filled to gas pressure in Mpa, uniformly distributed on the exterior ring surface of wheel.

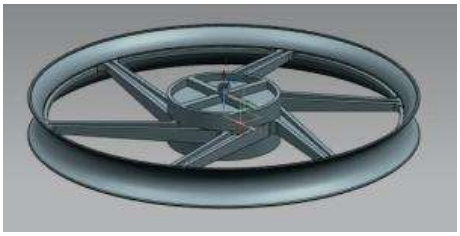
To ensure reliability of the analysis, the motor cycle is applied to the rear wheel alone. this is considered to be the maximum load, which was distributed on the rim surface.

In this velocity of motorcycle is considered as 90Kmph with different load conditions.

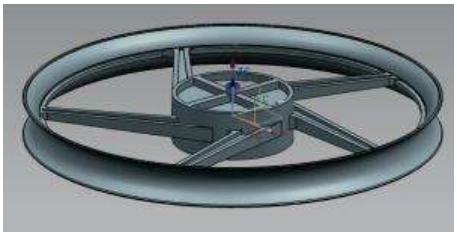
Fixed support in the hub shaft assembly.

III. MODELING AND ANALYSIS PROCEDURE

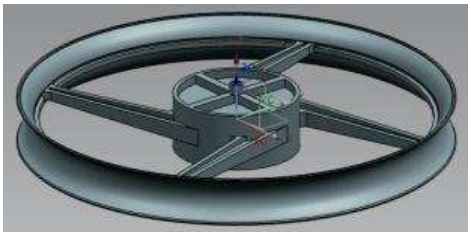
3.1 Created Designs



6 spokes

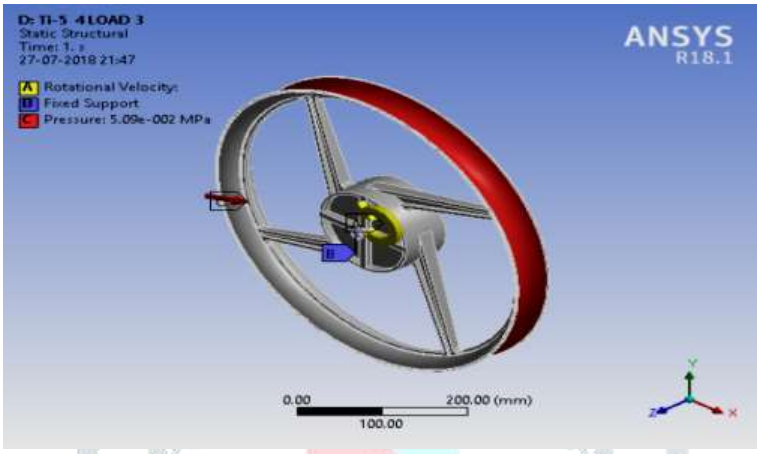


5 spokes



4 spokes

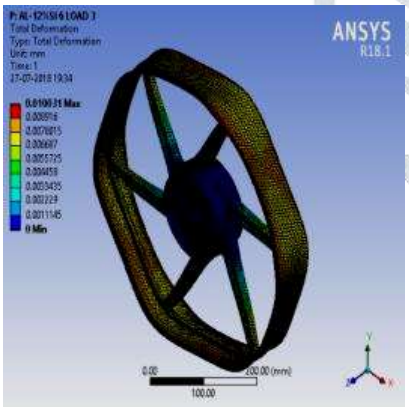
3.2 Loads on the Alloy Wheel



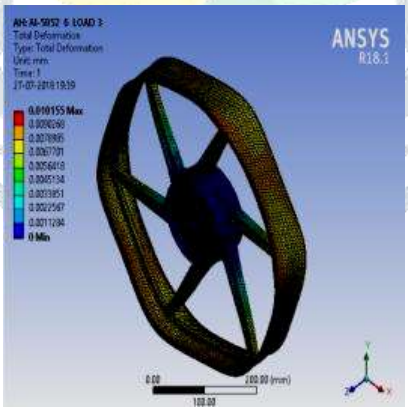
Loads with fixed supports are applied on wheel

3.3 analysis of wheel

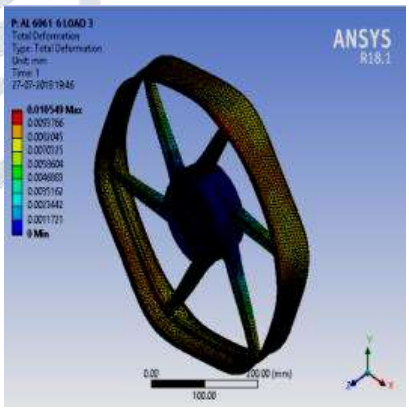
3.3.1 Equivalent Deformation on 6 Spoke



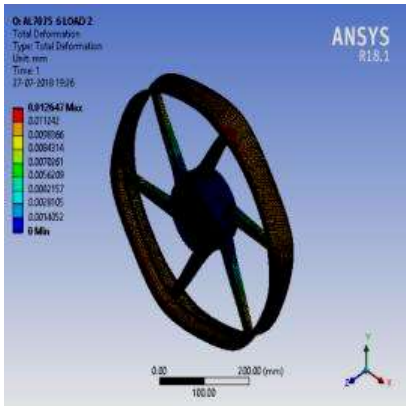
Al-12% Si Alloy wheel

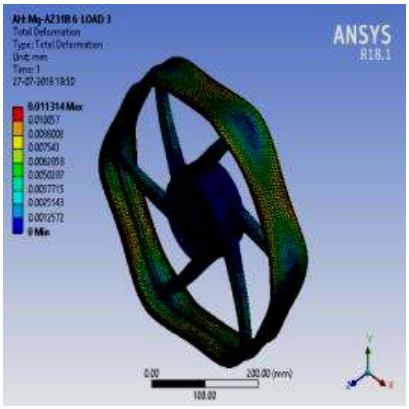


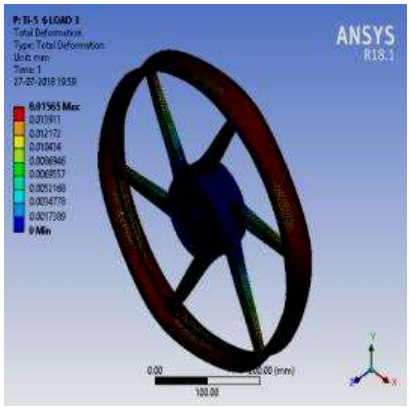
AL-5052 Alloy Wheel



AL-6061 Alloy Wheel

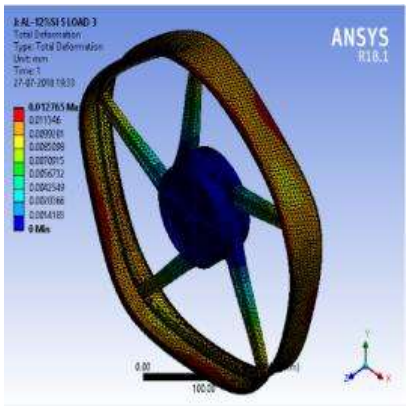




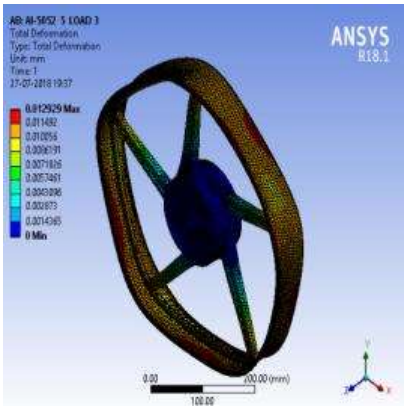


AL-7075 Alloy Wheel Mg-AZ31B Alloy Wheel Ti-5Al-2.5Sn Alloy Wheel

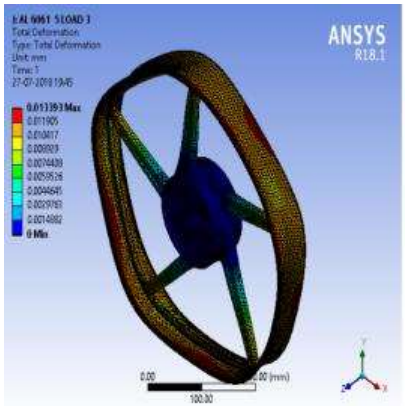
3.3.2 Equivalent Deformation on 5 Spoke



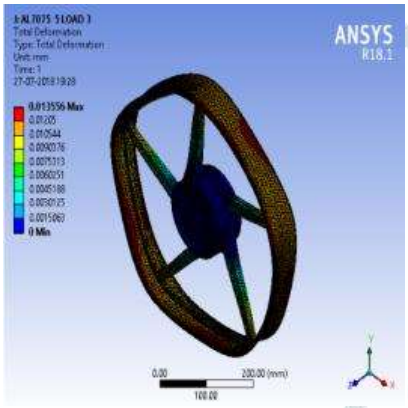
Al-12% Si Alloy wheel



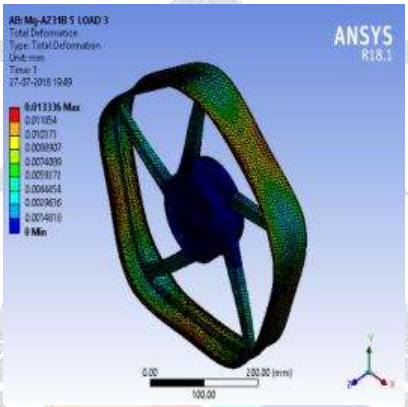
AL-5052 Alloy Wheel



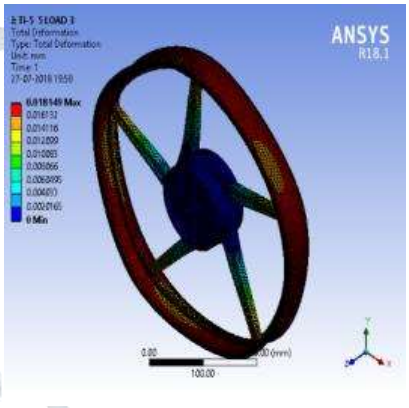
AL-6061 Alloy Wheel



AL-7075 Alloy Wheel

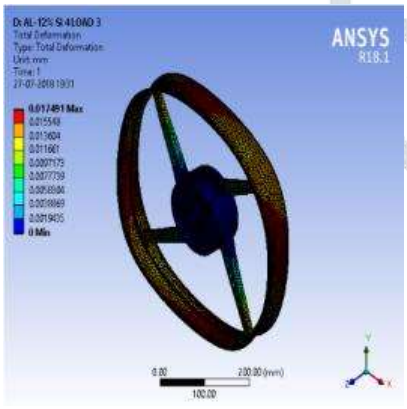


Mg-AZ31B Alloy Wheel

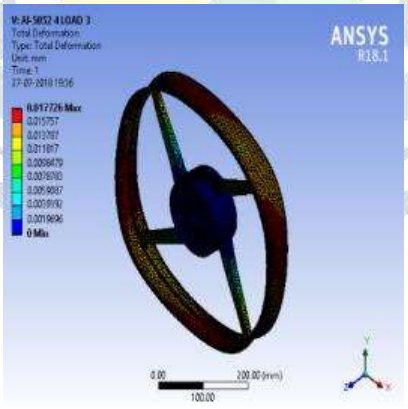


Ti-5Al-2.5Sn Alloy Wheel

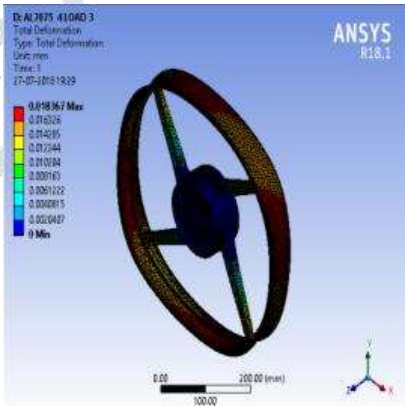
3.3.3 Equivalent Deformation on 4 Spoke



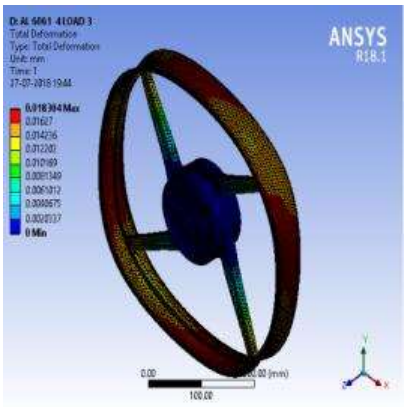
Al-12% Si Alloy wheel



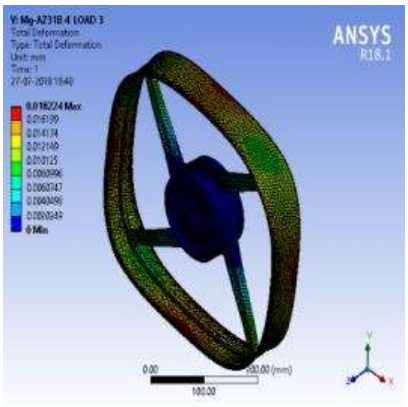
AL-5052 Alloy Wheel



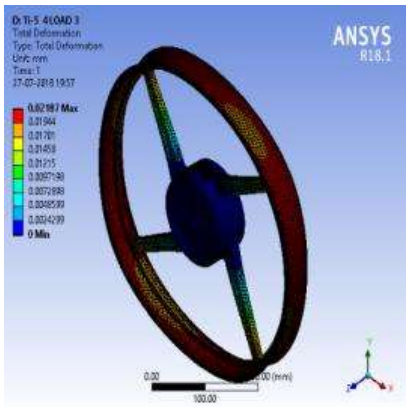
AL-6061 Alloy Wheel



AL-7075 Alloy Wheel



Mg-AZ31B Alloy Wheel

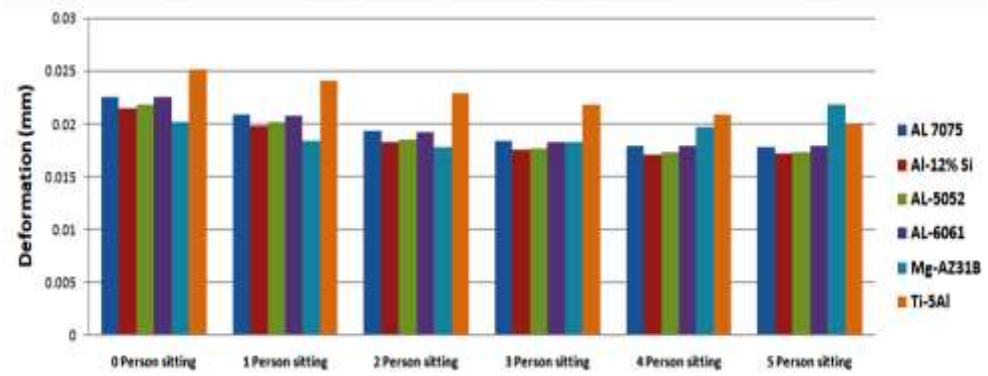


Ti-5Al-2.5Sn Alloy Wheel

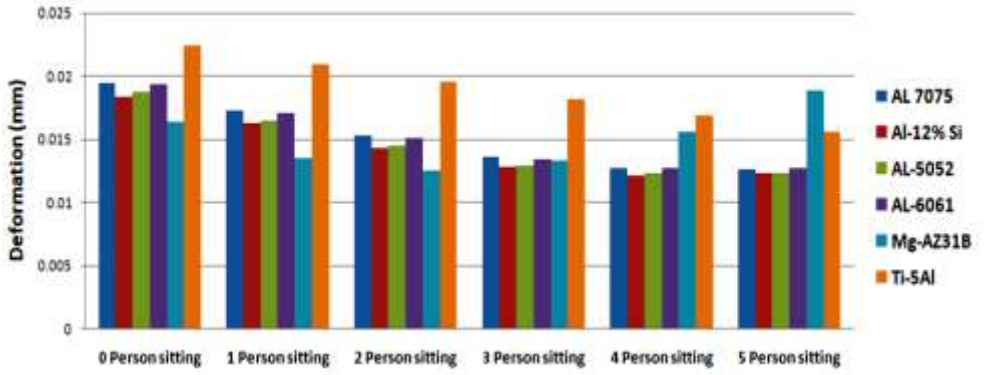
In above, solving the Total deformation from the Ansys 18.1; after that we will do the same procedure for all the Stress.

IV. RESULTS AND DISCUSSION

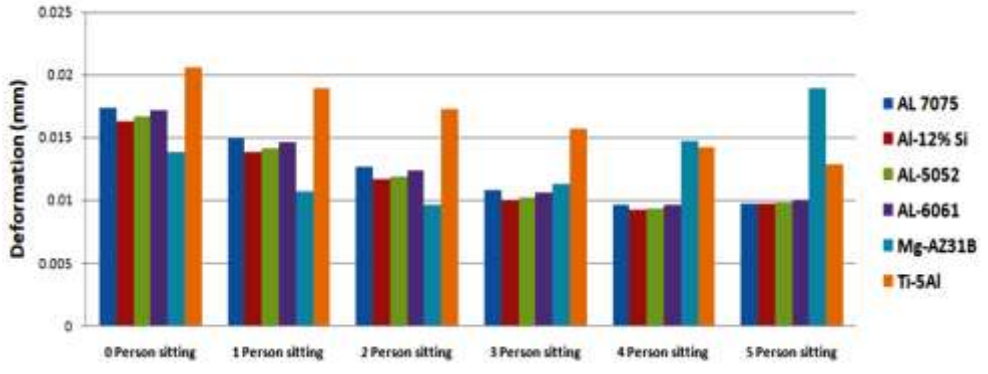
4.1 Deformation on Alloy wheel



Deformation on 4 spoke Alloy wheels

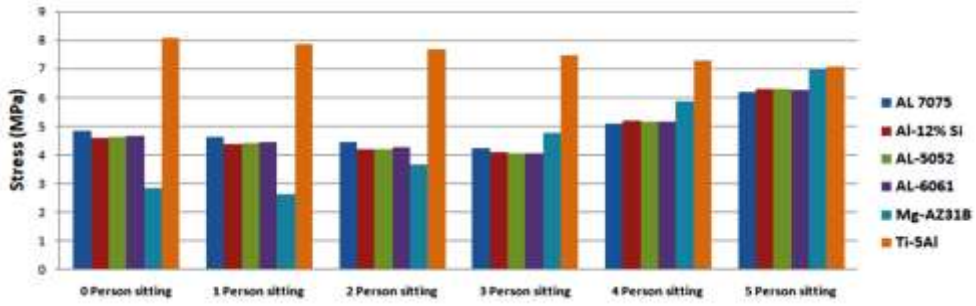


Deformation on 5 spoke Alloy wheels

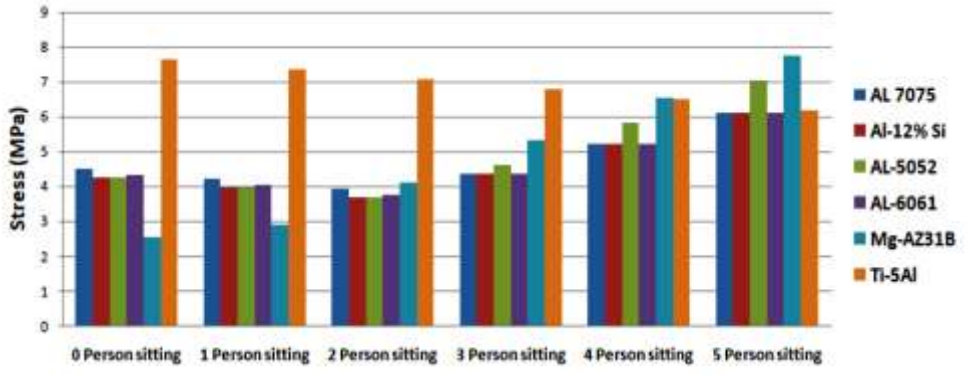


Deformation on 6 spoke Alloy wheels

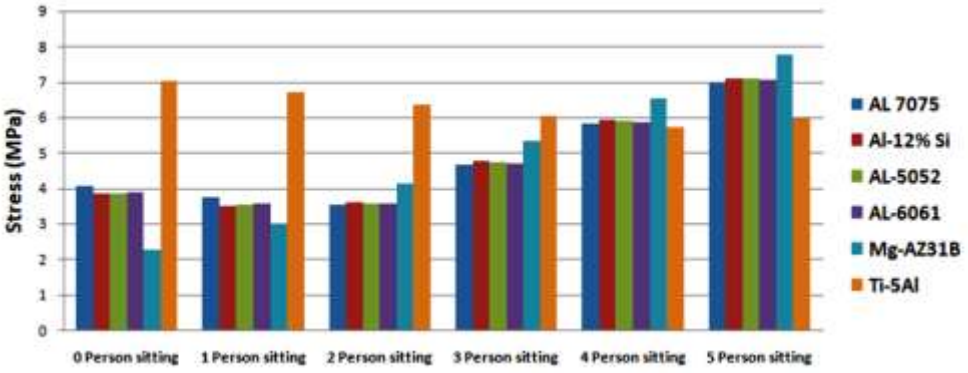
4.2 Stress on Alloy wheel



Stresses on 4 spoke Alloy wheels



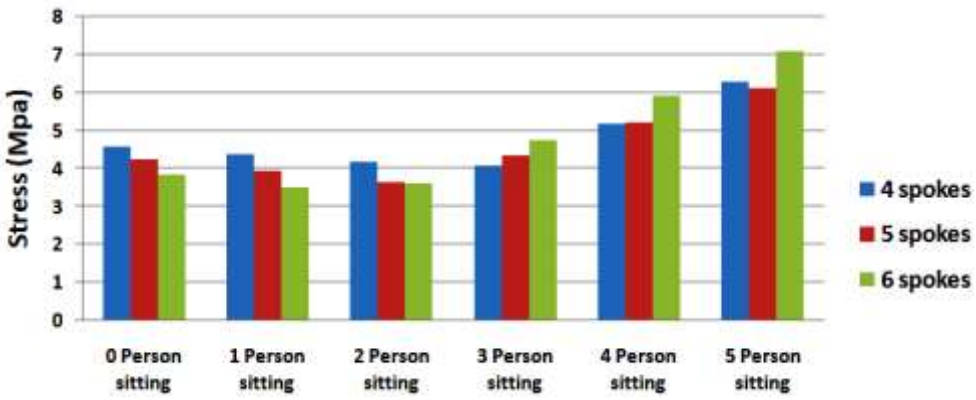
Stresses on 5 spoke Alloy wheels



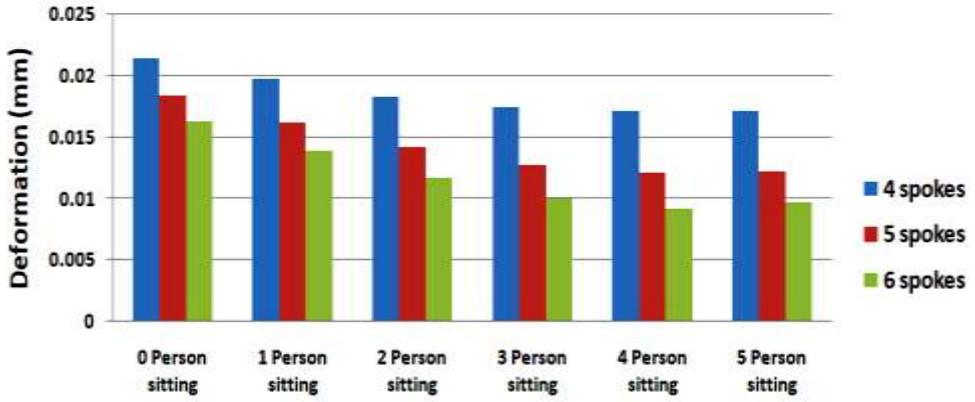
Stresses on 6 spoke Alloy wheels

4.3 Analysis of wheel According to material

4.3.1 Al-12% Si alloy material

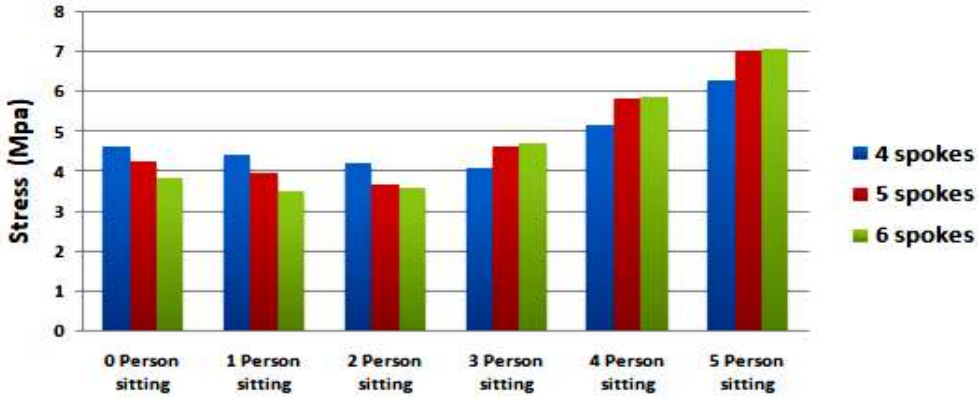


Stress on Al-12% Si Alloy wheels

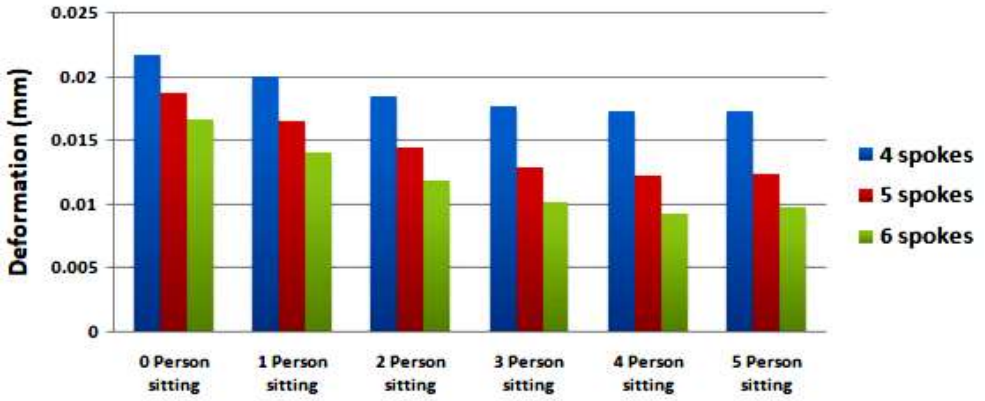


Deformation on Al-12% Si Alloy wheels

4.3.2 AL-5052 alloy material

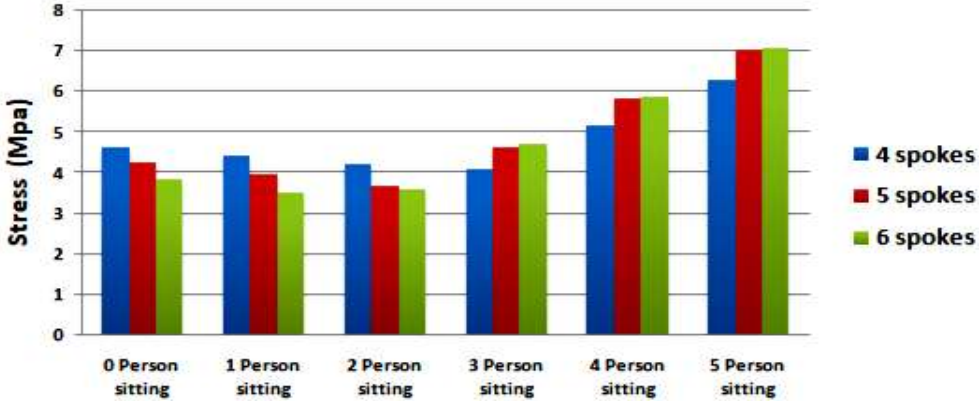


Stress on AL-5052 Alloy wheels

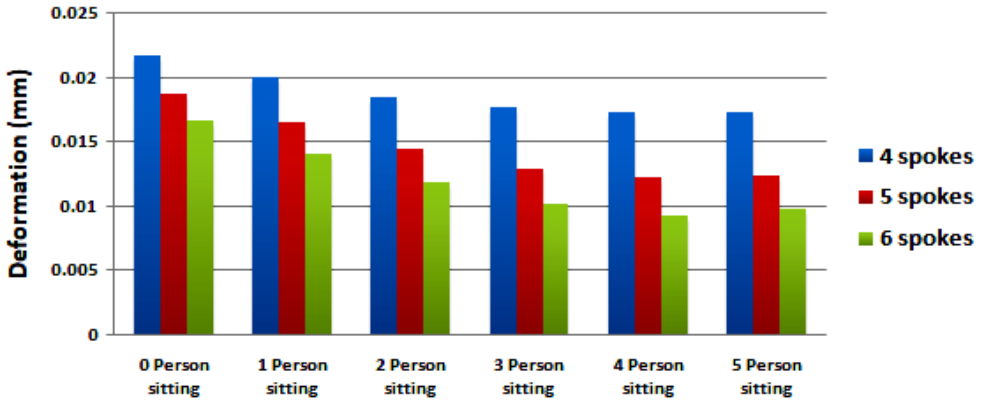


Deformation on AL-5052 Alloy wheels

4.3.3 AL-6061 alloy material

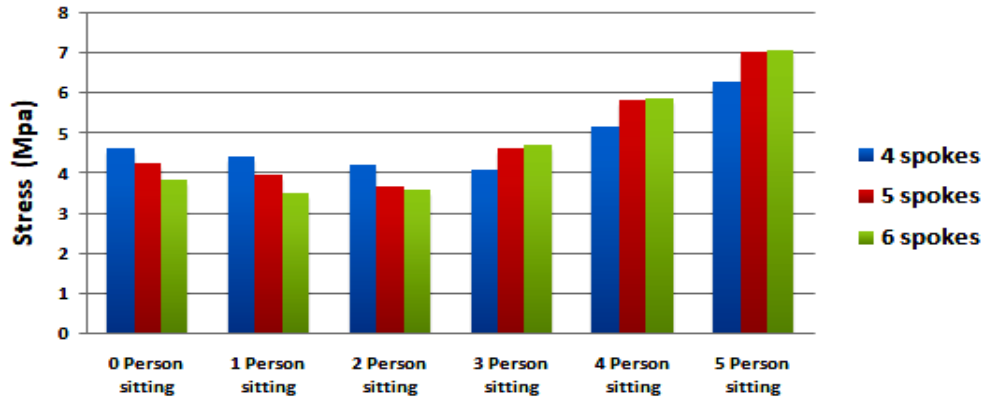


Stress on AL-6061 Alloy wheels

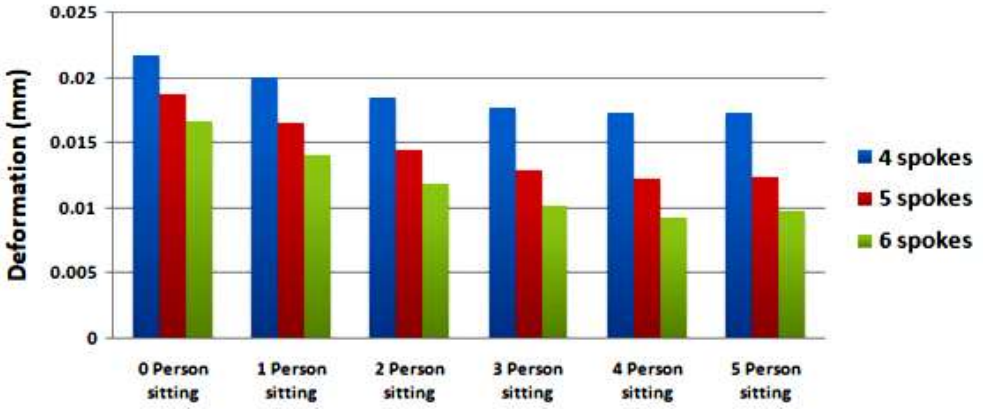


Deformation on AL-6061Alloy wheels

4.3.4 AL-7075 alloy material

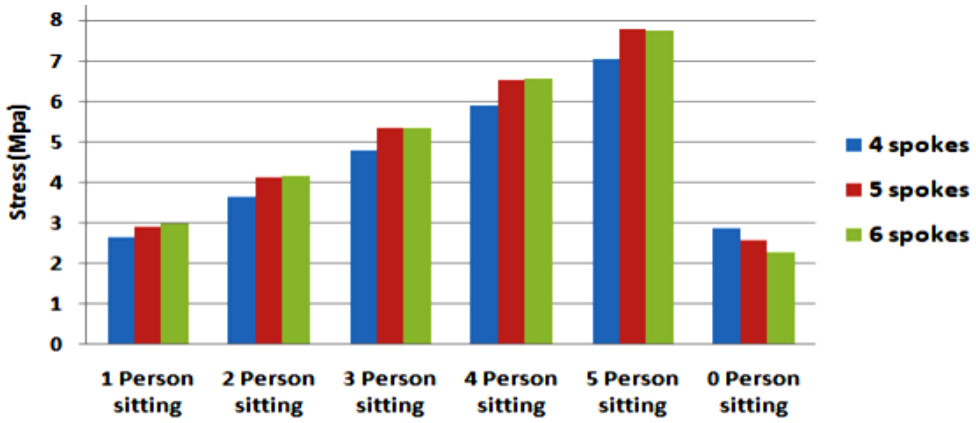


Stress on AL-7075Alloy wheels

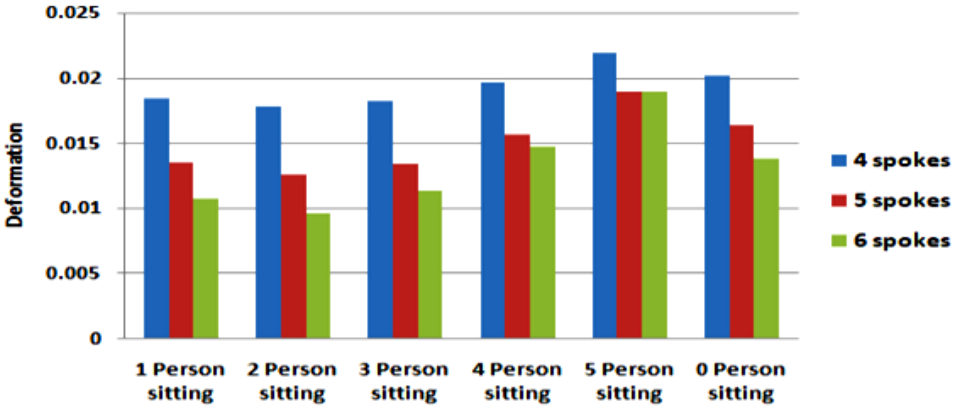


Deformation on AL-7075Alloy wheels

4.3.5 Mg-AZ31B alloy material

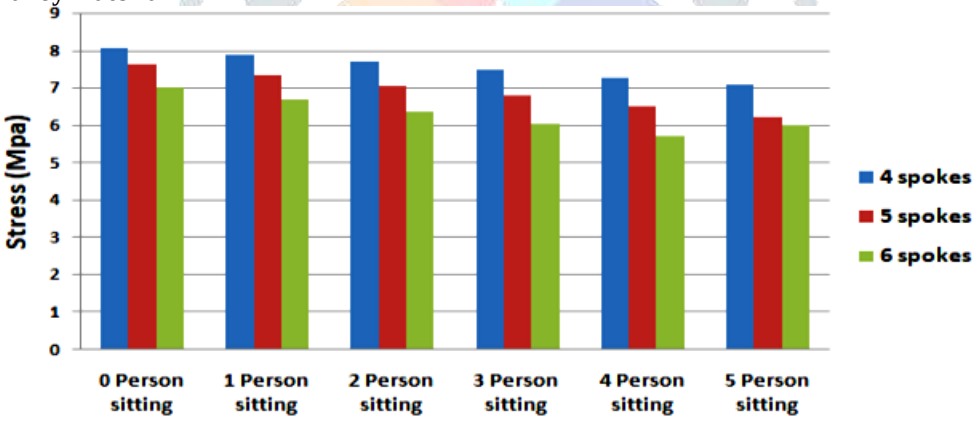


Stress on Mg-AZ31B Alloy wheels

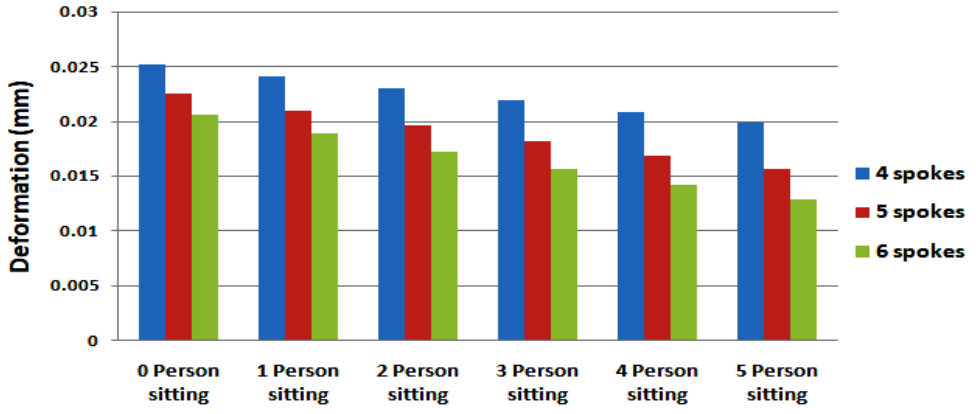


Deformation on Mg-AZ31B Alloy wheels

4.3.6 Ti-5Al-2.5Sn alloy material



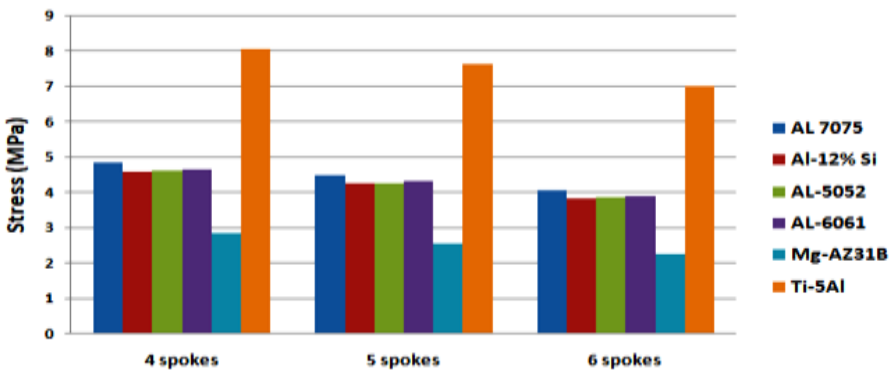
Stress on Ti-5Al-2.5Sn Alloy wheels



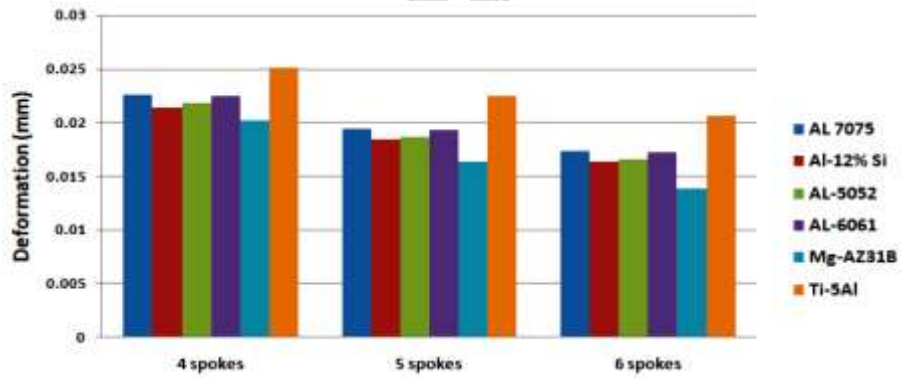
Deformation on Ti-5Al-2.5Sn Alloy wheels

4.4 Analysis of wheel According to load

4.4.1 Load acting on the wheel when“0 person” sitting (Bike weight only)

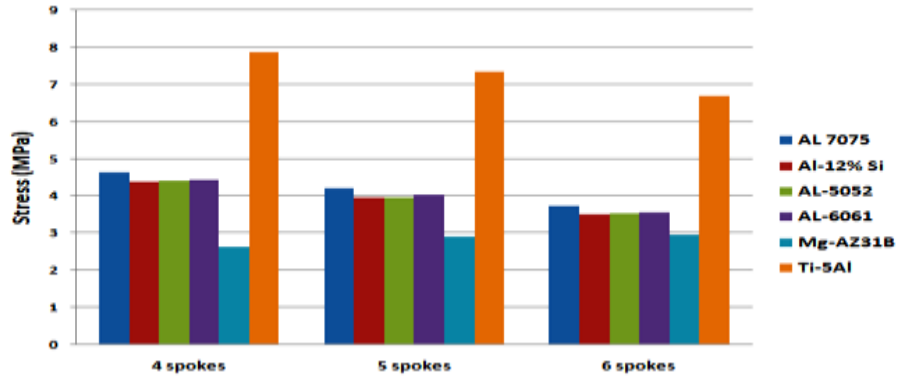


Stresses on Wheel when 0 person sitting (bike weight only)

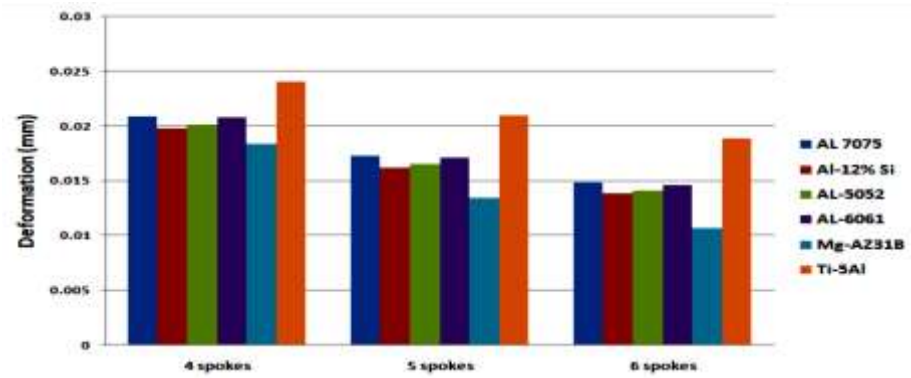


Deformation on Wheel when 0 person sitting (bike weight only)

4.4.2 Load acting on the wheel when“1 person” sitting (Bike weight +1 person)

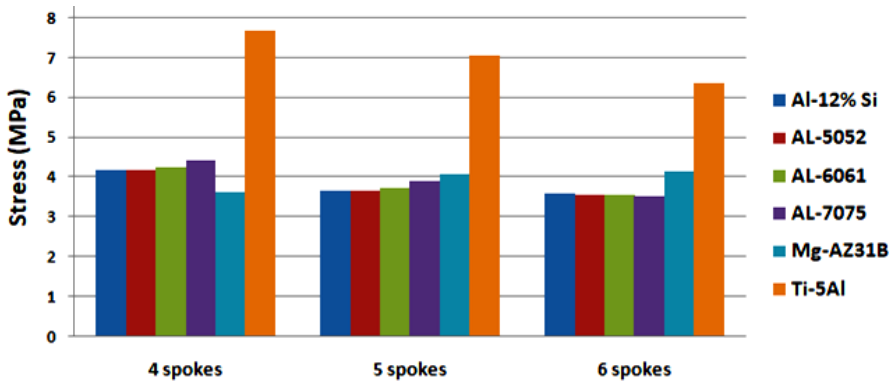


Stresses on Wheel when1 person sitting

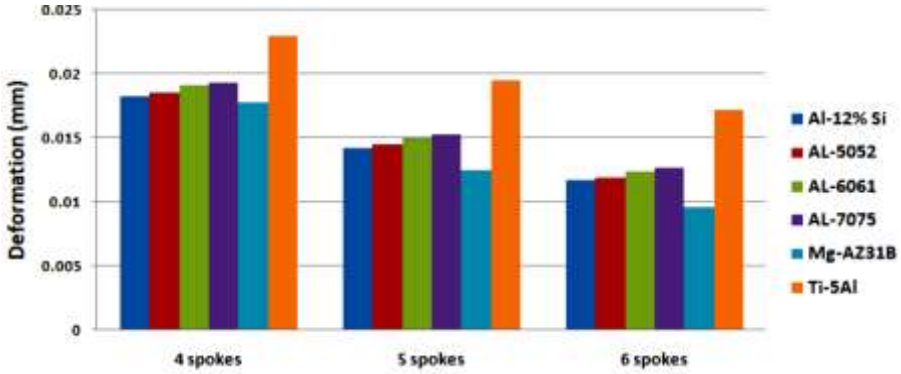


Deformation on Wheel when 1 person sitting

4.4.3 Load acting on the wheel when"2 person" sitting (Bike weight +2 person)

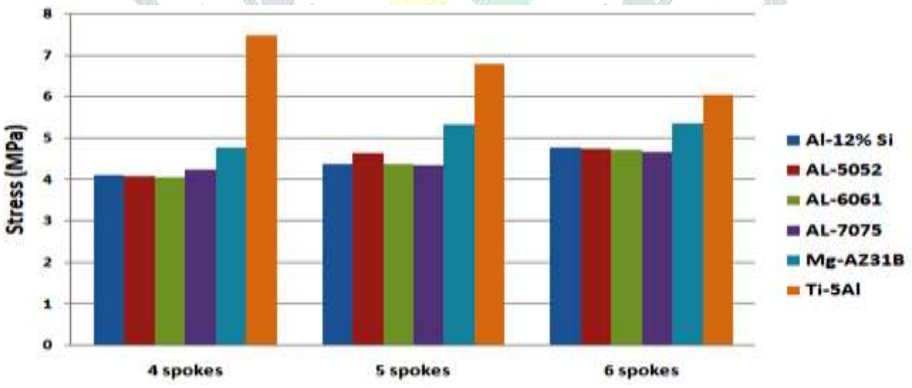


Stresses Wheel when on 2 person sitting

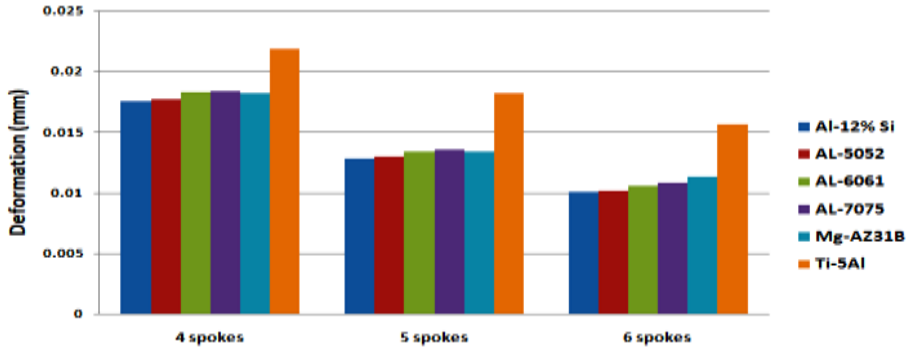


Deformation on Wheel when 2 person sitting

4.4.4 Load acting on the bike when"3 person" sitting (Bike weight +3 person)

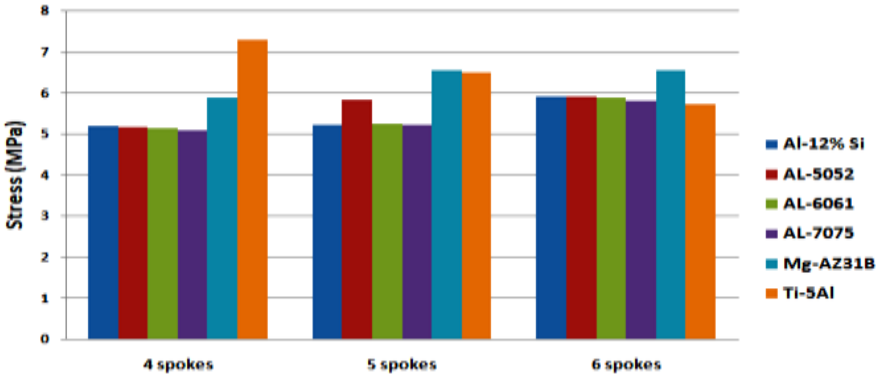


Stresses on Wheel when 3 person sitting

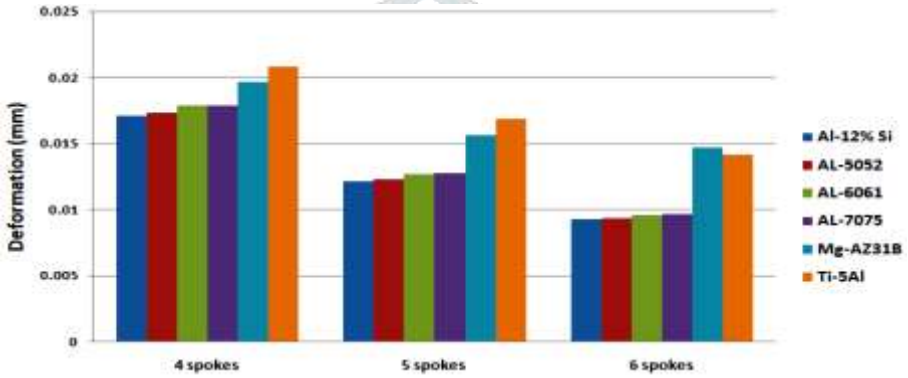


Deformation on Wheel when 3 person sitting

4.4.5 Load acting on the bike when"4 person" sitting (Bike weight +4 person)

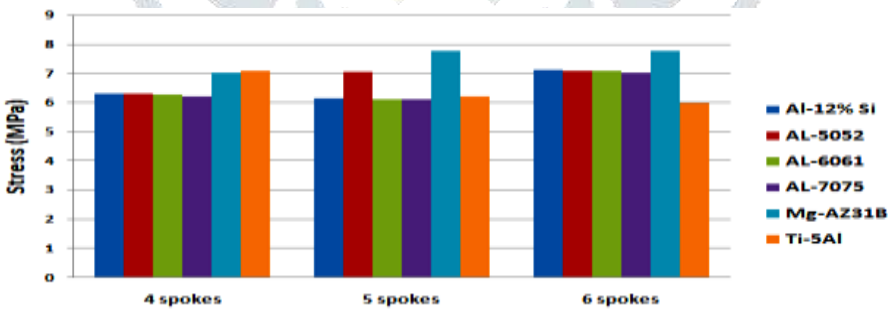


Stresses on Wheel when 4 person sitting

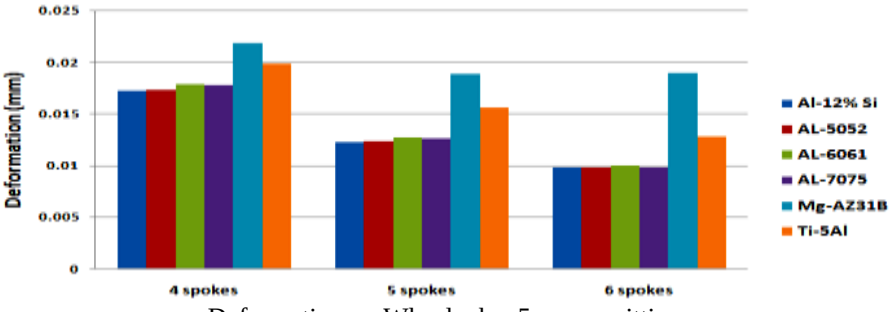


Deformation on Wheel when 4 person sitting

4.4.6 Load acting on the bike when"5 person" sitting (Bike weight +5 person)



Stresses on Wheel when 5 person sitting

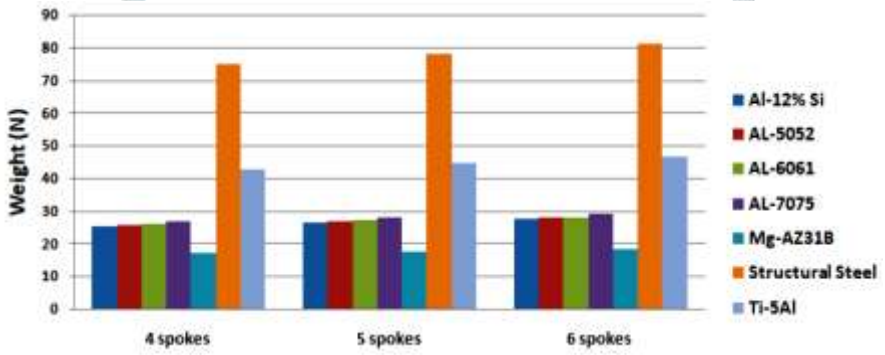


Deformation on Wheel when5 person sitting

4.5 Percentage of Weight saving of alloy wheels

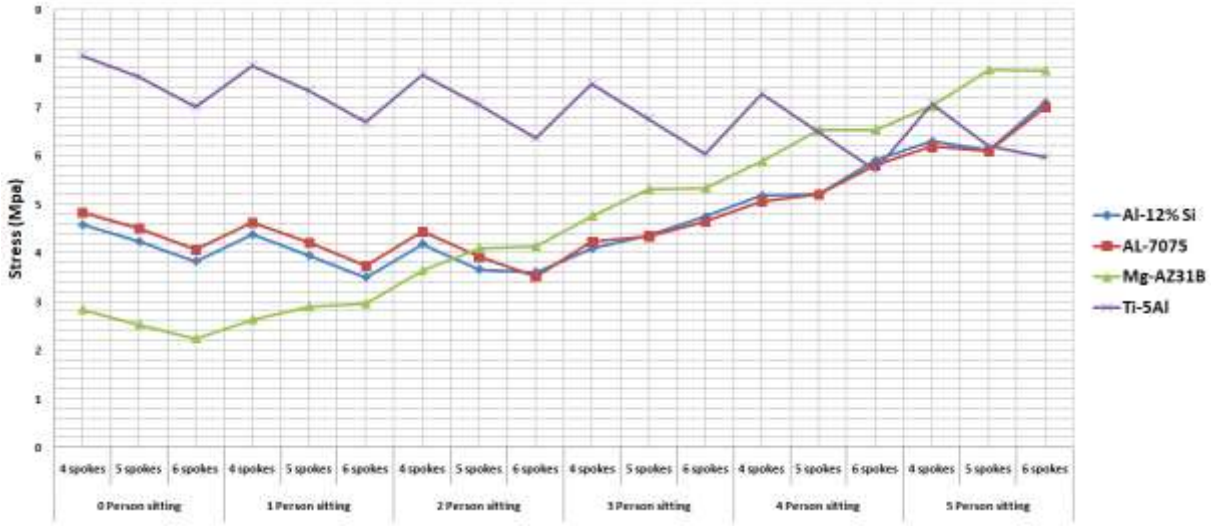
S No.	Material	Spokes	weight (N)	% of weight of savage compared to the Ti-5Al-2.5Sn (6 spokes)
1	Mg-AZ31B	4 spokes	16.88	63.62%
2	Mg-AZ31B	5 spokes	17.61	62.06%
3	Mg-AZ31B	6 spokes	18.33	60.49%
4	Al-12% Si	4 spokes	25.32	45.44%
5	AL-5052	4 spokes	25.59	44.87%
6	AL-6061	4 spokes	25.85	44.30%
7	Al-12% Si	5 spokes	26.41	43.09%
8	AL-5052	5 spokes	26.69	42.49%
9	AL-7075	4 spokes	26.78	42.30%
10	AL-6061	5 spokes	26.96	41.90%
11	Al-12% Si	6 spokes	27.50	40.74%
12	AL-5052	6 spokes	27.79	40.12%
13	AL-7075	5 spokes	27.93	39.82%
14	AL-6061	6 spokes	28.08	39.51%
15	AL-7075	6 spokes	29.08	37.33%
16	TI-5AL-2SN	4 spokes	42.74	7.93%
17	TI-5AL-2SN	5 spokes	44.57	3.96%
18	TI-5AL-2SN	6 spokes	46.41	0.00%

Weight of alloy wheels in ascending order of Weight and % weight savage.

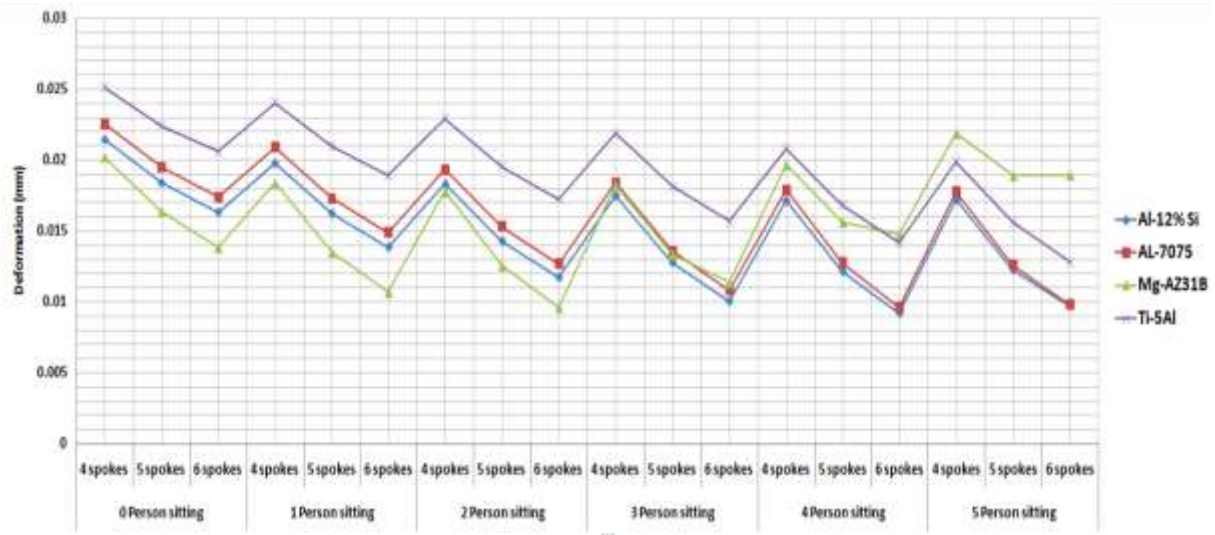


Weight of different spokes with Different Materials

4.6 Selected Best Materials with Stress, deformation and Loading conditions



Stress vs. Loading Condition with spokes



Deformation vs. Loading Condition with spokes

V. CONCLUSION:

From the above Loading Conditions for Low Loading Conditions MG-AZ31B is best material, For medium Range Loading Condition AL-12%Si will be best suitable, AL7075 Also Exhibits similar Properties i.e. we can use both materials for medium range use, and TI-5AL-2SN suitable for High Loading conditions for the wheel, for the spokes wise we will use 5 spokes will satisfying all the conditions of alloy wheel for the above materials

MG-AZ31B is best upto 2 person sitting on bike, due to low weight and high toughness then the other materials it has low stress and deformation. It is suitable for low loads like scooty 100-150cc Engine.

AL-12%Si, AL7075 exhibits same stress and deformation at all conditions. These materials are in suitable between MG-AZ31B and TI-5AL-2SN. So those are suitable for medium Loads like 150-250cc Engine bikes wheels.

TI-5AL-2SN is best for high loads, because it exhibits low stress. It suitable for high Loads like above 350cc Engine wheels.

From weight analysis, MG-AZ31B having 60.49%, AL-12%Si is 40.74% and AL7075 having 37.33% weight savage compared to the TI-5AL-2SN (6 spokes)

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