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Analysis of Design Modification of Motor Cycle Wheel Spokes

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ABSTRACT

Spoke is one of some number of rods radiating from the center of a wheel connecting the hub with the round traction surface. The term originally referred to portions of a log which had been split lengthwise into four or six sections. The radial members of a wagon wheel were made by carving a spoke into their finished shape. Eventually, the term spoke was more commonly applied to the finished product of the wheelwright's work, than to the materials he used.

A double control forming technology of motorcycle wheel was firstly developed to form the complex parts with high mechanical properties. The Materials used for alloy wheels AZ91D Magnesium alloy and AM60B alloy are used and compared and while form double control forming. The effect of pressure on the mechanical properties and microstructure of the parts formed by double control forming using ANSYS and compared with Analytical approach. When a pressure of 4000KN was applied, check the strength of best smart material from using ANSYS software. Results are compared with Analytical approach. Find out best material from this study.

INTRODUCTION

In the present research, a double control forming technology was proposed, by which not only the complex part but also the high mechanical properties were achieved. In addition, the effect of pressure on the micro structure and mechanical properties of parts formed by double control forming was investigated.

MOTORCYCLE WHEEL

Motorcycle wheels are made to cope with radial and axial forces. They also provide a way of mounting other critical components such as the brakes, final drive and suspension. Wheels, and anything directly connected to them, are considered to be unsprung mass. Traditionally motorcycles used wire-spoked wheels with inner tubes and pneumatic tyres [1]. Although cast wheels were first used on a motorcycle in 1927, it would not be until the 1970s that mainstream manufacturers would start to introduce cast wheels on their road going motorcycles. Spoked wheels are usually made using steel spokes with steel or aluminium rims. Cast wheels are predominantly made from an aluminium-alloy, but can also be made from more-exotic materials, such as magnesium content alloy or carbon fibre [2].

Fig 1.2: alloy wheel

SPOKE

wire gauge	diameter	section area
15G	1.8 mm	3.24 mm²
14G	2.0 mm	4 mm²
13G	2.3 mm	5.29 mm²
12G	2.6 mm	6.76 mm²
11G	2.9 mm	8.41 mm²
10G	3.2 mm	10.24 mm²

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LITERATURE REVIEW

Jufu Jiang and Yuansheng Cheng [1] have performed the analysis on Effect of Pressure on Microstructure and Mechanical Properties of AM60BAlloy Used for Motorcycle Wheels Formed by Double Control Forming. A set of novel forming die combining the advantages of dies casting and forging was designed, by which double control forming idea was firstly proposed. The motorcycle wheel made of AM60B alloy was used as the typical component to demonstrate advantages of the double control forming. The effect of pressure on the mechanical properties and microstructure of the parts formed by double control forming was investigated. The results showed that high mechanical properties and complex shape were achieved in the parts formed by double control forming. Compared to die casting, the mechanical properties of the formed part significantly increased and the microstructure changed from the coarse dendrites to fine equi-axed grains. The shrinkage voids and micro cracks in the formed parts were obviously reduced or even completely eliminated with the increase of pressure. When a pressure of 4000 kN was applied, the optimal mechanical properties such as ultimate tensile strength of 265.6 MPa and elongation of 21% were achieved and the microstructure was characterized by fine and uniform equi-axed grains due to the large under cooling degree caused by the high pressure

ManjunathBatli et al.,[2] in their research work, created the 3D model of the wheel and analysed it by applying various load on it and remodeled the same to reduce the deformation . The material was changed from titanium to Al7075. The Al 7075 consisted of 6% zinc, 2.4% magnesium, 1.5% copper, 0.4% silicon, iron, manganese, titanium, chromium. The data obtained indicate that, the alloy Al 7075(Yield Strength=503MPa) has high strength to weight ratio when compared with magnesium alloy (230 MPa). Al7075 is cheap compared to magnesium alloy. Al 7075 International Journal of Innovations in Engineering and Technology (IJIET) http://dx.doi.org/10.21172/ijiet.82.017 Volume 8 Issue 2 April 2017 114 ISSN: 2319 - 1058 was more robust and long lasting, whereas it wasn't the case in magnesium alloy. The authors have conclude that Al 7075 can be used as an alternative material in place of magnesium alloy.

ANALYTICAL APPROACH

Magnesium AZ91D

Magnesium is a silvery-white chemical element with the symbol Mg and atomic number 12. Magnesium alloys contain magnesium as the chief metal along with alloy elements such as lead, aluminum, zinc, and other non-ferrous alloys.

Magnesium alloys in the past were used only as cast alloys; however, with advanced technology available today, the wrought alloy version is also used. Magnesium AZ91D alloy is a cast alloy type.

Physical Properties

Properties	Metric	Imperial
Density	1.81 g/cm³	0.0654 lb/in³
Melting point	≥ 421 °C	≥ 790 °F

Thermal Properties

Properties	Metric
Thermal expansion co-efficient (at 0.000-100°C/ 32-212°F)	25.2 µm/m°C
Thermal conductivity	72.3W/mK

Mechanical Properties

Properties	Metric	Imperial
Tensile strength	230 MPa	33400 psi
Yield strength (at strain 0.200 %)	160 MPa	21800 psi
Elastic modulus	44.8 GPa	6500 ksi
Shear modulus	17 GPa	2470 ksi
Poisson's ratio	0.35	0.35
Elongation at break (in 50mm)	3%	3%
Hardness, Brinell	63	63
Hardness, Knoop (estimated from Brinell)	84	84
Hardness, Rockwell E	75	75
Hardness, Vickers (estimated from Brinell)	71	71

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MagnesiumAM60B

Magnesium AM60B cast alloy has excellent ductility, superior energy absorbing properties, and good strength and cast ability.The following sections will discuss in detail about magnesium AM60B cast alloy.

Properties	Metric	Imperial
Density	1.80 g/cm³	0.065 lb/in³

Thermal Properties

Properties	Metric	Imperial
Thermal expansion co-efficient (@20-100°C/68-212°F)	26 µm/m°C	14.4 µin/in°F
Thermal conductivity (@20°C/68°F)	61 W/mK	422 BTU in/hr.ft².°F

Mechanical properties

Properties	Metric	Imperial
Tensile strength	225-240 MPa	33-35 ksi
Yield strength	130 MPa	18 ksi
Elastic modulus	45 GPa	6526 ksi
Elongation	8-13 %	8-13 %
Hardness	65	65

Applications

Magnesium AM60B cast alloy is chiefly used in several components in the automobile sector. The following are some of them:

- Brackets
- Seat frames
- Instrument panels
- Steering wheels

EXAMPLE

GEOMERY PROPERTIES OF ALLOY WHEEL

Hub Diameter	120mm
Hub thickness	8mm
Rim thickness	6mm
Rim outer diameter	500 mm
Spoke Length	155 mm
Spoke fillet radii at hub	5R
Spoke fillet radii at outer rim	7R & 13R

For Strength:

Mass of Bike, Dead Weight of Bike =143kg

Other Loads = 20 Kg

Total Gross Weight =143 + 20 = 163 Kg = 163X 9.81 N

Tires and Suspension system reduced by 30% of Loads

W_{net} = 163 X 9.81 X 0.7 N = 1119.32 N

Reaction Forces On Bike = N_r = 1119.32 N

Number of Wheels: 2

But by considering total Reaction Force on only one wheel FT =1119.32N

Rim surface area which is having 6 spokes: A6 = 48299.69 mm2 (this can be obtained from selecting faces on rim by using measuring tool in solid works)

Stress on the each Rim = $\frac{N_r}{A} = \frac{1119.32}{48299.69} = 0.02321$ N/mm^2

Rotation Velocity = $\frac{v}{r}$

For men accelerate motor cycle from 0 to 80km/hr

Rotation velocity = $\frac{80 \times \left(\frac{5}{18}\right)}{0.250} = \frac{22.22}{0.250} = 88.88$ rad/sec

Applying Braking Torque

In general Acceleration of the street motor cycle: a = (v_f - v_i) / t

v_f- final velocity= max of 60miles in 3.5sec

v_i- initial velocity = 0 miles,

a - acceleration = 7.6636m/s^2

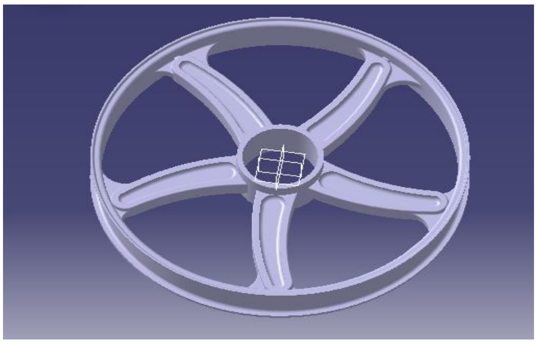
Brake force is required to estimate the load on the wheel hub.

Now Total force acting on the vehicle:

Mass of the vehicle including rider and other five more persons M= 163+ (65 X 6)

F_{total} =M * a = 4237.9 N

DESIGN OF ALLOY WHEEL WITH 5 SPOKES



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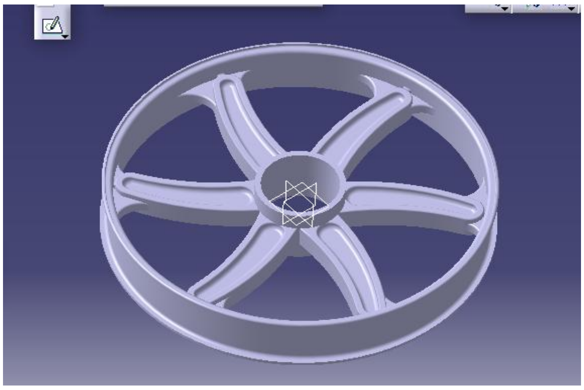
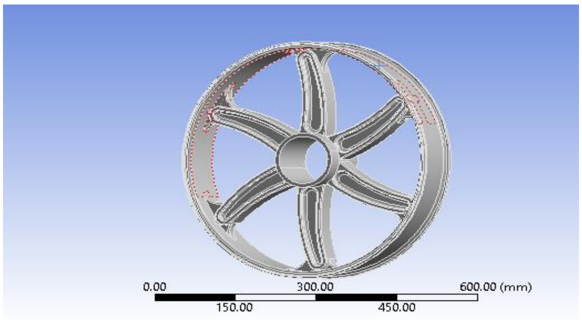
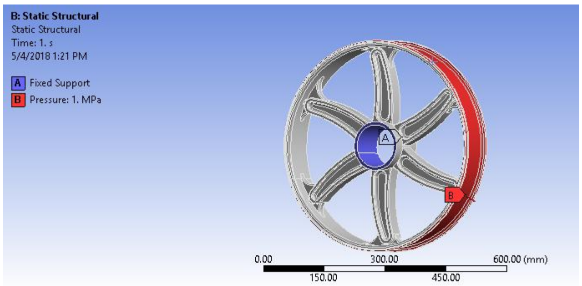


RESULTS

ALLOY WHEEL WITH 5 SPOKES

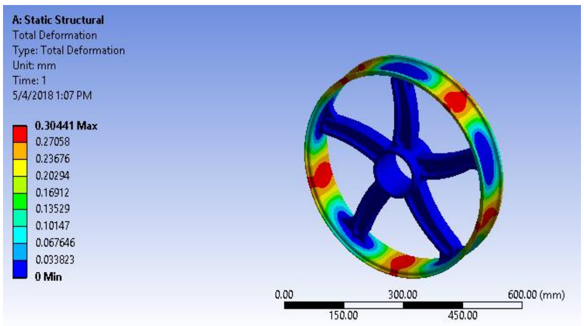


Imported model

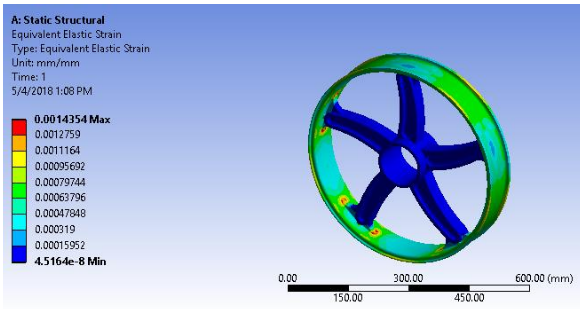


load and boundary conditions

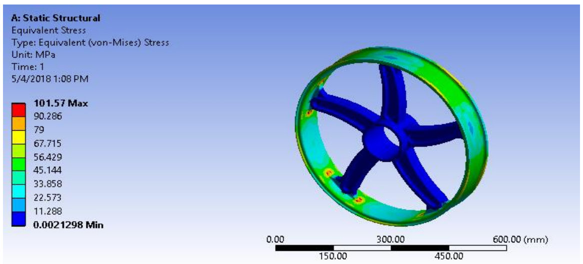
MATERIAL: ALUMINIUM



Maximum deformation is 0.30441mm

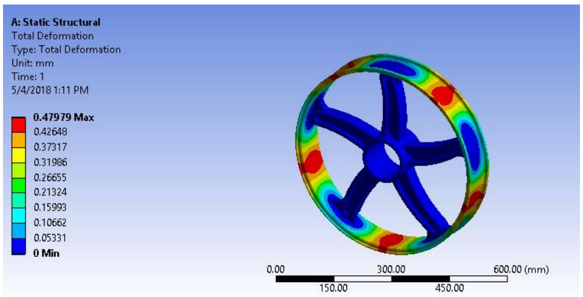


Maximum von mises strain is 0.0014354

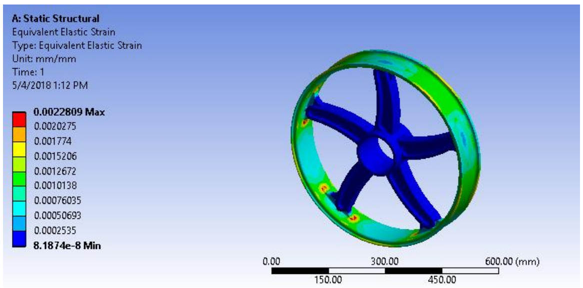


Maximum von mises stress is 101.57Mpa

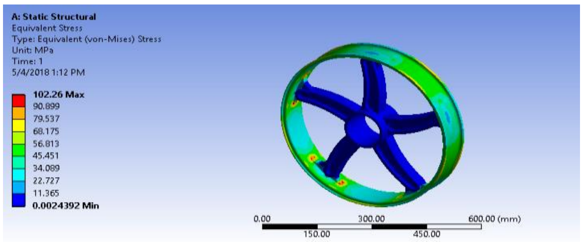
MATERIAL: MAGNESIUM ALLOY



Maximum deformation is 0.47979mm



Maximum von mises strain is 0.0022809 Mpa



Maximum von mises stress is 102.26 Mpa

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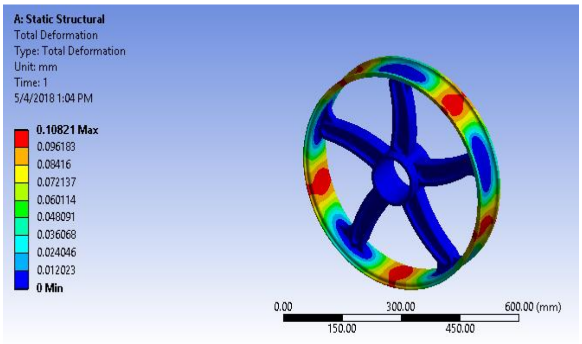
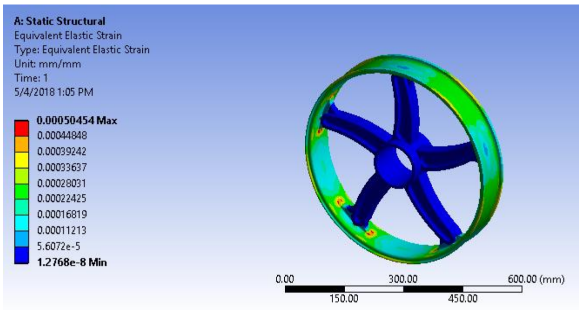
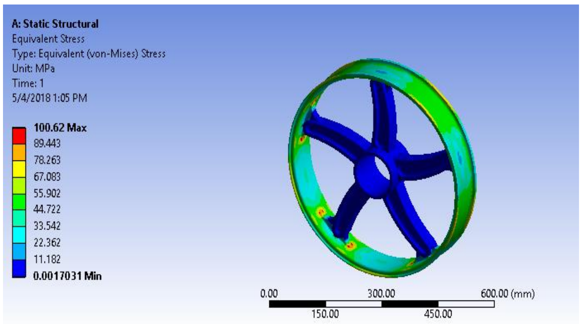
MATERIAL: STEEL



Maximum deformation is 0.10821mm



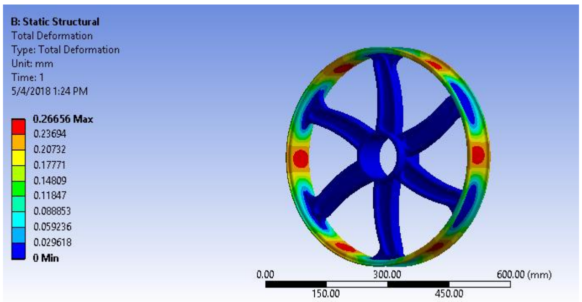
Maximum von mises strain is 0.00050454 Mpa



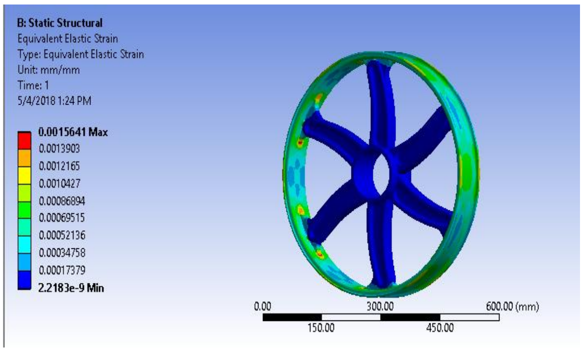
Maximum von mises stress is 100.62 Mpa

ALLOY WHEEL WITH 6 SPOKES

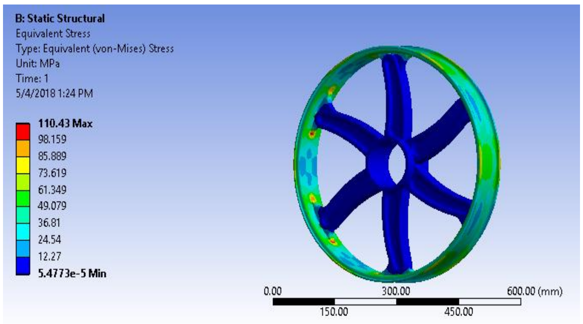
MATERIAL: ALUMINIUM



Maximum deformation is 0.26656mm

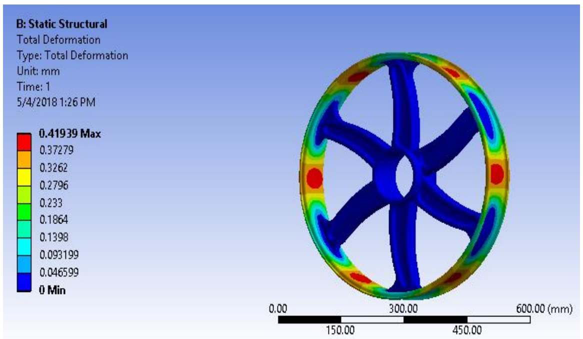


Maximum von mises strain is 0.0015641 Mpa

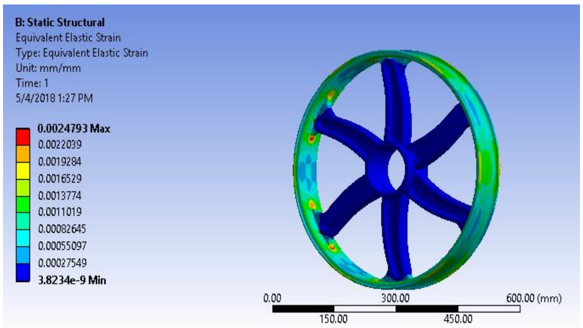


Maximum von mises stress is 110.43 Mpa

MATERIAL: MAGNESIUM ALLOY



Maximum deformation is 0.41939 mm



Maximum von mises strain is 0.0024793 Mpa

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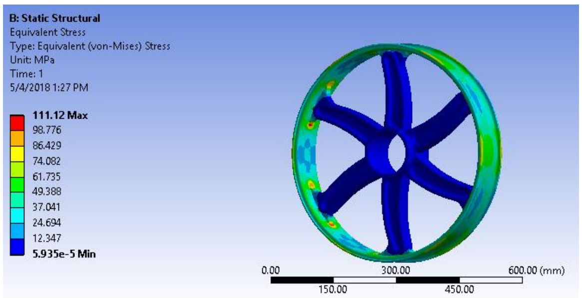
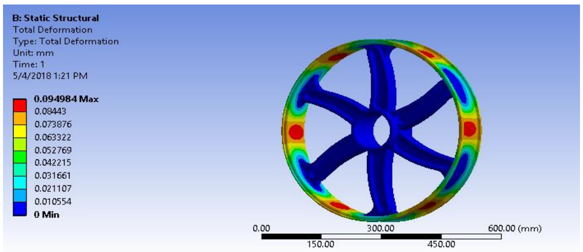
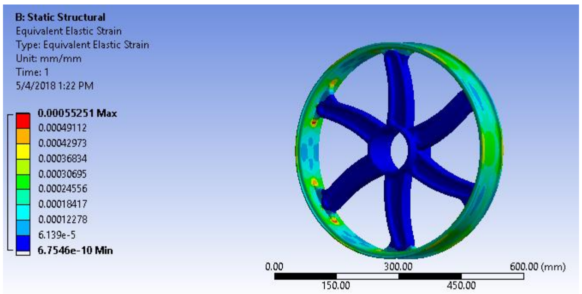


Maximum von mises stress is 111.12 Mpa

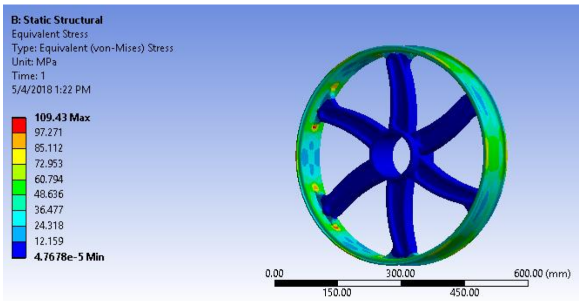
MATERIAL: STEEL



Maximum deformation is 0.094984 mm



Maximum von mises strain is 0.00055251 Mpa

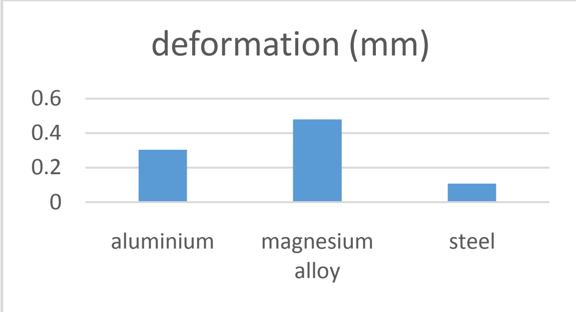


Maximum von mises stress is 109.43 Mpa

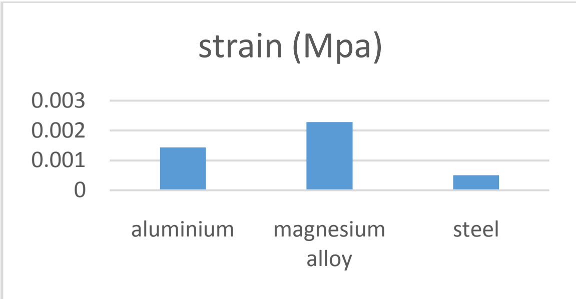
RESULTS TABLE

s.no	material	5 spokes			6 spokes		
		deformation (mm)	strain (Mpa)	stress (Mpa)	deformation (Mpa)	strain (Mpa)	stress (Mpa)
1	aluminium	0.30441	0.0014354	101.57	0.26656	0.0015641	110.43
2	magnesium alloy	0.47979	0.0022809	102.26	0.41939	0.0024793	111.12
3	steel	0.10821	0.00050454	100.62	0.094984	0.00055251	109.43

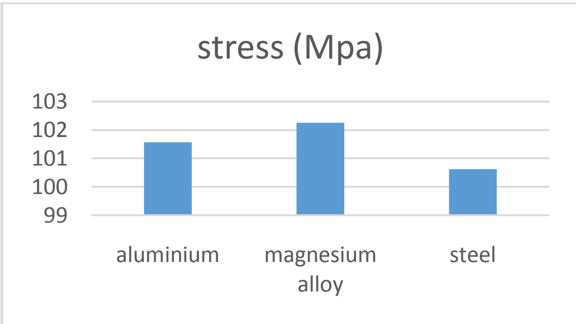
Comparison of Deformation of 5 spokes with materials



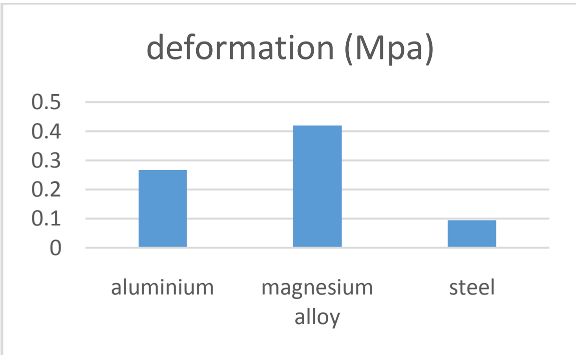
Comparison of strain of 5 spokes with materials



Comparison of Stress of 5 spokes with materials



Comparison of Deformation of 6 spokes with materials



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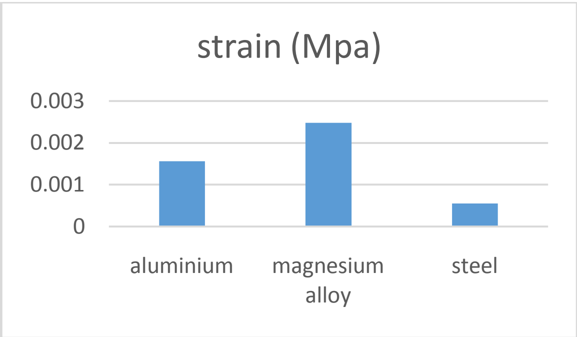
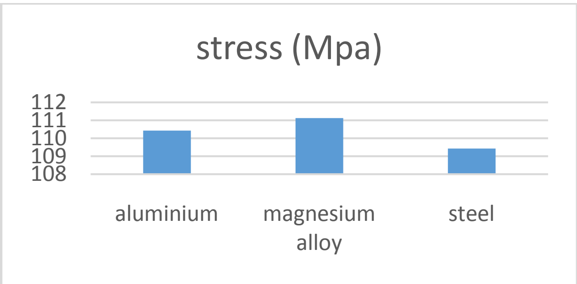
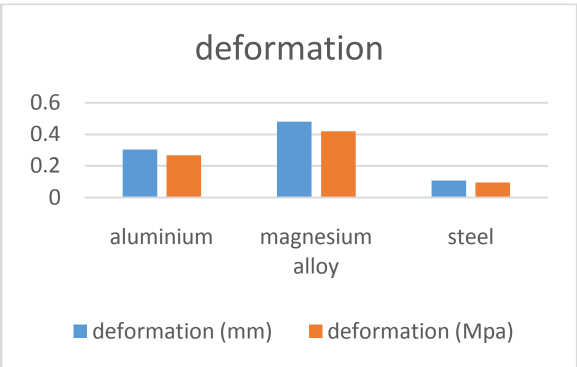
Comparison of Strain of 6 spokes with materials



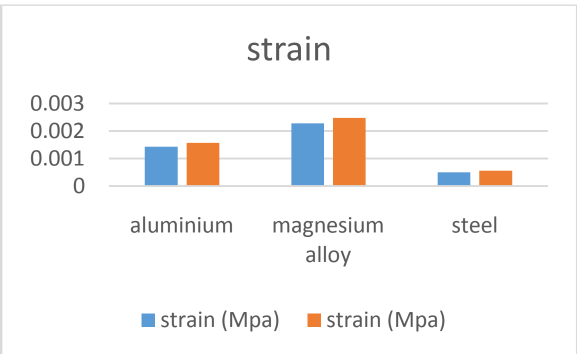
Comparison of Stress of 6 spokes with materials



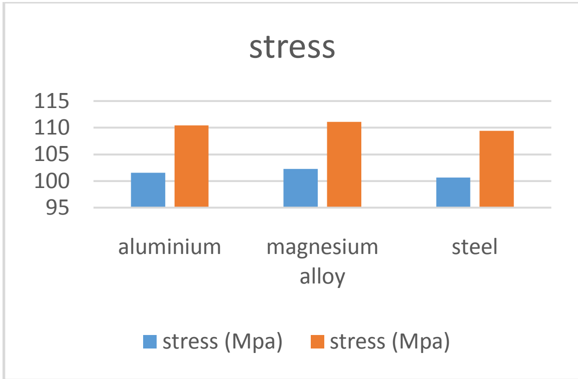
Comparison of Deformation of 5 & 6 spokes with materials



Comparison of Strain of 5 & 6 spokes with materials



Comparison of Stress of 5 & 6 spokes with materials



CONCLUSION

The filling advantage of DC and densifying advantage of forgin were combined together in the DCF. High mechanical properties and complex shape wer all achieved in the components formed by DCF

- The maximum stress area was located at Spoke-Rim contact.
- Stresses induced in 5Spokes Alloy wheel are less as compared with Al-Alloy of the 6 Spokes.
- The modified design to the wheel is less than normal design of the Al-alloy wheel of the rim.
- Induced Stress due to braking torque in the 5 Al-Spoke wheels are lesser than the remaining wheels.
- Material reduction can be done by reducing number of Spokes. The objective was to reduce the weight of the alloy wheel has been achieved.

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