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# Model and Structural Analysis of Two-Wheeler (Motorcycle) Rim using ANSYS Software

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**Abstract -** *Wheels play a vital role of vehicle suspension which guides the static and dynamic load during vehicle action. Conventional materials are used to produce the wheel rim, these are heavy in weight due to this over all weight of the vehicle is increases. Heavy weight of vehicle effect the fuel consumption, light weight vehicle delivers high mileage as compare to high weight vehicle with same capacity engine. Today the prices of fuels are increasing day by day so there are huge demands of cheep and fuel efficient vehicle. Regarding this scenario, reduction in weight of vehicle is the best step for achievement of cheep and fuel efficient vehicle. In a motorcycle engine is the heaviest unit after this wheel of motor cycle is the second heaviest unit. Wheel rim can be replaced from conventional materials to composite materials.*

*Polyetheretherketone (PEEK) is the best composite material for replacement of conventional materials wheel rim. PEEK has unique combination of mechanical properties, resistance to chemicals, wear, fatigue and creep as well as exceptionally high temperature resistance, up to 260°C (480°F). PEEK is selected due to their superior mechanical properties, durability and light in weight.*
*In this paper entire wheel rim design for two wheeler rim was chosen and analyzed by applying different load and redesign the wheel rim again to minimize the deformation and material will be changed from aluminum to PEEK (polyether ether ketone)*

*Wheel rim design for two-wheeler is made by using NX 7.5, and Analysis has been done by ANSYS 14, software to determine the various stresses, strain and fatigue life of the wheel rim. The software has helped us really to achieve our goal. As the whole analysis is done by the means of software therefore result and observations are trustworthy and meet with our expectation.*

***Key Words***: Aluminium Alloy, Wheel Rim, PEEK, *ANSYS 14, etc.*

## 1. INTRODUCTION

The wheel is a part that permits efficient movement of an object across a surface where there is a force pressing the object to the surface. The spoke wheel rim assembly contributes the major weight addition in motorcycle after the engine. To overcome this disadvantage alloy wheels are invented. While comparing all alloy materials aluminum alloy is the best of other alloy materials [1].

The design of a motorcycle wheel contains several complexes and attempt has been made to meet the requirements of original equipment manufacturers (OEMs).By using UNIGRAPHICS (NX 7.5), it involves with the drawing requirements and design of a motorcycle wheel. The design in 6 degree of freedom (DOF) for characteristics and durability has been developed [2].

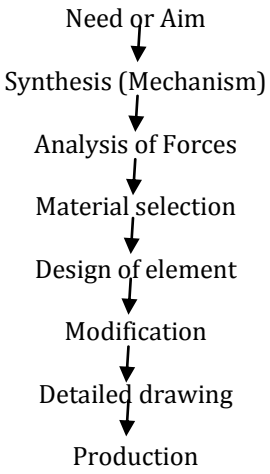
Automobile industry has a pressure for reduction in cost and to produce fuel efficient vehicles. Composite materials are the combination of two or more metals or nonmetals is known as composite materials. Generally composite materials are lighter and stronger than conventional metals. Thermoplastic composite materials consist of thermoplastic resins as matrix, reinforcement with traditional fibers as thermo sets matrix. They have shown great promise as materials for current and future automotive, aerospace and industrial applications. Composite material wheel is different from the light alloy wheel [3] and it is developed mainly for low weight. However, this wheel has inadequate consistency against heat and for best strength. PEEK (polyether ether ketone) polymer continues to successfully replace steel, aluminum, bronze, titanium, and other high–performance materials, because it offers an ideal combination of mechanical, thermal and aluminum spokes logical properties, combined with excellent resistance to grease, oils, acids and all other automotive fluids. PEEK is an ideal replacement for Aluminum alloy. PEEK is particularly useful in the automobile industry for its weight.

PEEK is three different types:
1. PEEK with 30% Glass fiber,
2. PEEK–90 HMF 20% Carbon fiber
3. PEEK–90 HMF 40% Carbon fiber

Lighter wheels can improve handling by reducing unstrung mass , allowing suspension to follow the terrain more closely and thus improve grip, however not all alloy wheels are lighter than their steel equivalents. Reduction in overall vehicle mass can also help to reduce fuel consumption [4].

## 2. EXPERIMENTAL

### 2.1 Steps used in Design




### 2.2 Design Processer

Vernier calipers used for measurement of Aluminum alloy wheel rim dimensions. As per the profile dimensions rim is drawn on the screen of the computer using UNIGRAPHICS (NX 7.5). After completion of rim drawing the model is imported in the ANSYS software.

### 2.3 Aluminium Alloy Wheel Analysis

First of all take the Aluminum alloy material composition i.e. LM 13 Material composition of LM13 is Al-Si (BS: LM13) alloy was used as the matrix material. The alloy contains 11.00 wt.% Si, 1.00wt.% Mg, 1.50 wt.% Ni, 1.00 wt.% Cu, 0.80wt.% Fe, 0.50 wt.% Mn and balance was Al.

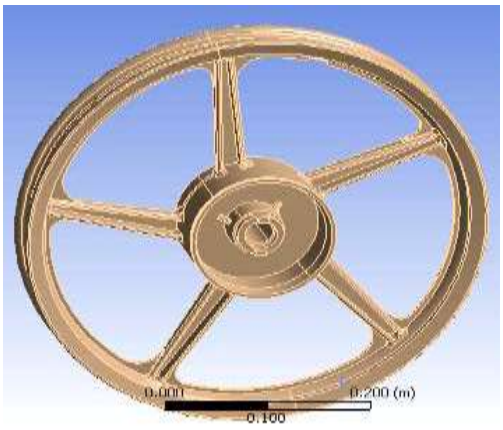


**Fig-1**: 3D Model of Actual Wheel

**Table-1:** Design Parameters of Aluminum Alloy Wheel

| Particulars | dimensions |
|---|---|
| Rim outer diameter | 462mm |
| Rim width | 57mm |
| Hub diameter | 144mm |
| Spokes length | 121mm |
| Angle between two spokes | 76.510 |

### 2.4 Stress Analysis of Actual wheel

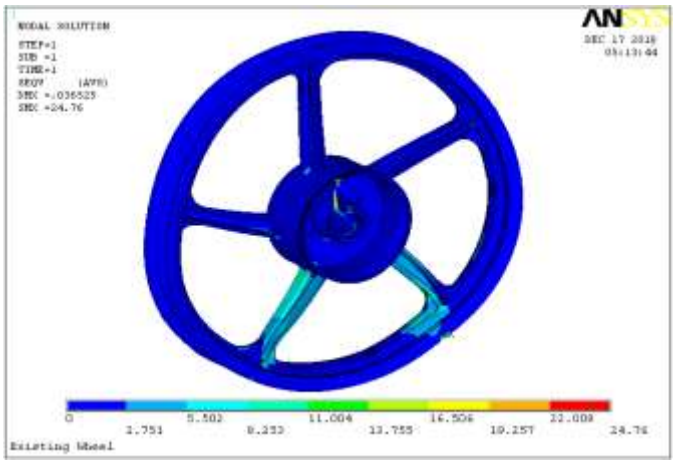


**Fig-2**: Equivalent Stress in Al-Alloy wheel at 250Kg load = 24.76MPa

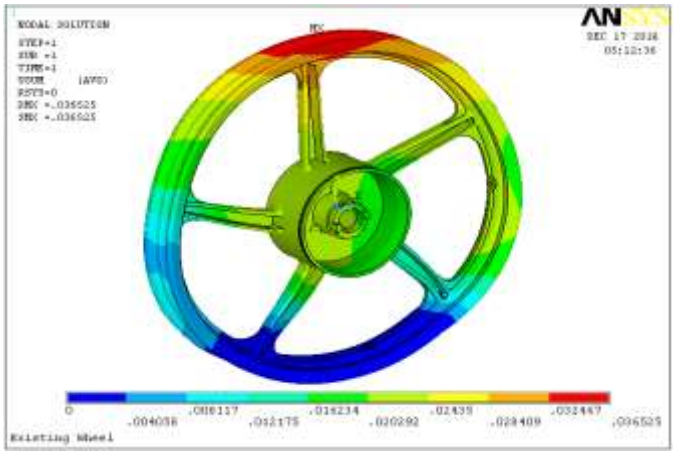


**Fig-3**: Total Deformation in Al-alloy wheel at 250Kg load =0.03652mm.

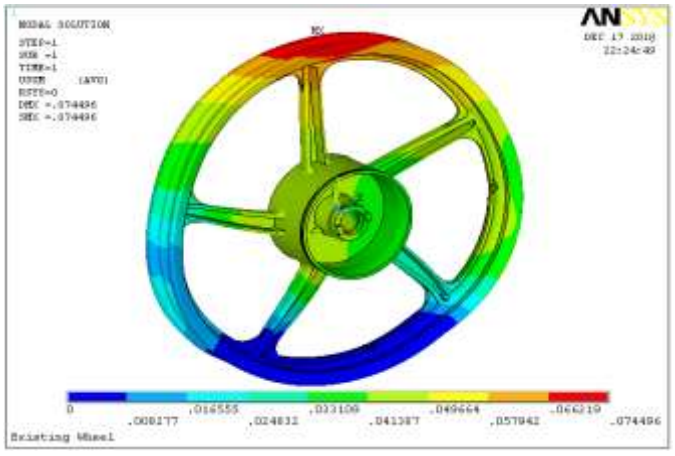


**Fig-4:** Total Deformation in Polyetheretherketone wheel at 250Kg = 0.074496mm

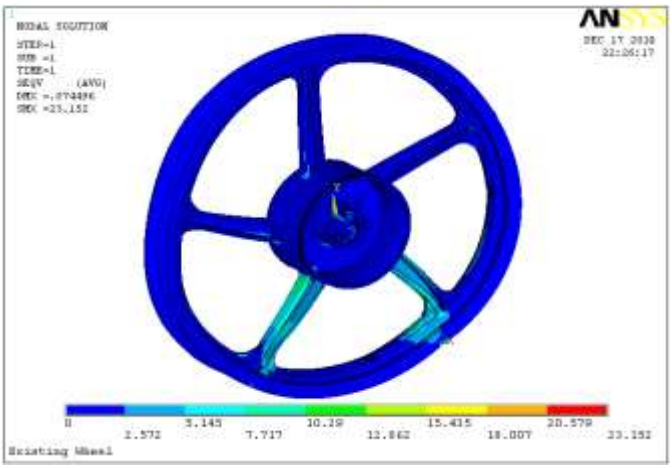


**Fig-5:** Equivalent Stress in Polyetheretherketone wheel at 250Kg =23.152Mpa

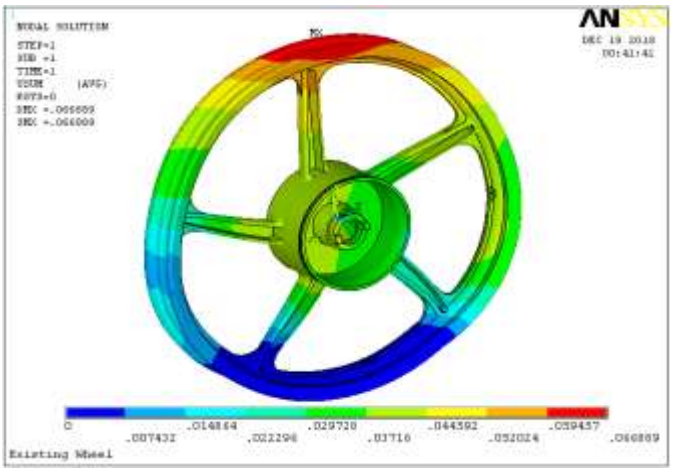


**Fig-6:** Total Deformation of PEEK 30% Glass Fiber Wheel at 250Kg (2452.50N) = 0.066889mm

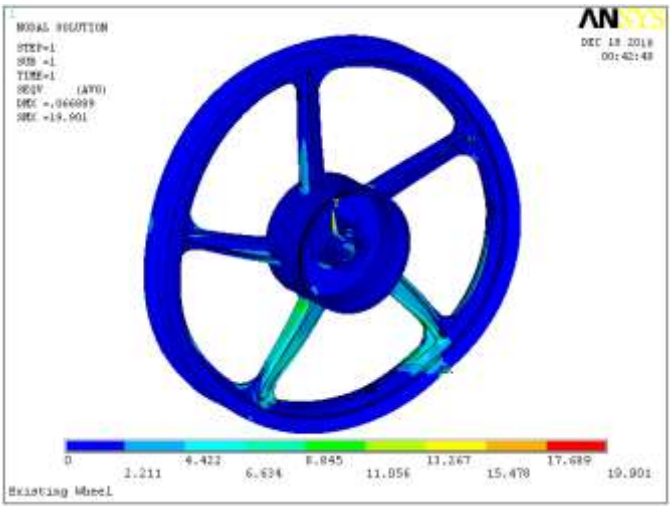


**Fig-7:** Equivalent Stress in PEEK 30% Glass Fiber Wheel at 250Kg(2452.5 N) = 19.901Mpa

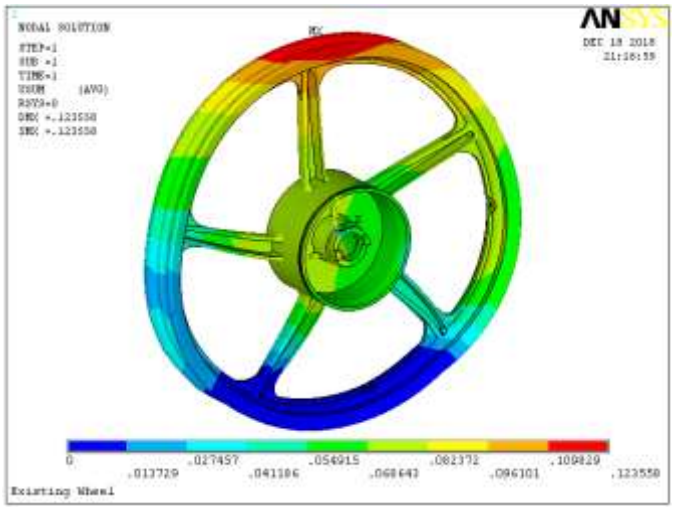


**Fig-8:** Total Deformation of PEEK90HMF20 Wheel at250Kg (2452.5N) = 0.123558mm

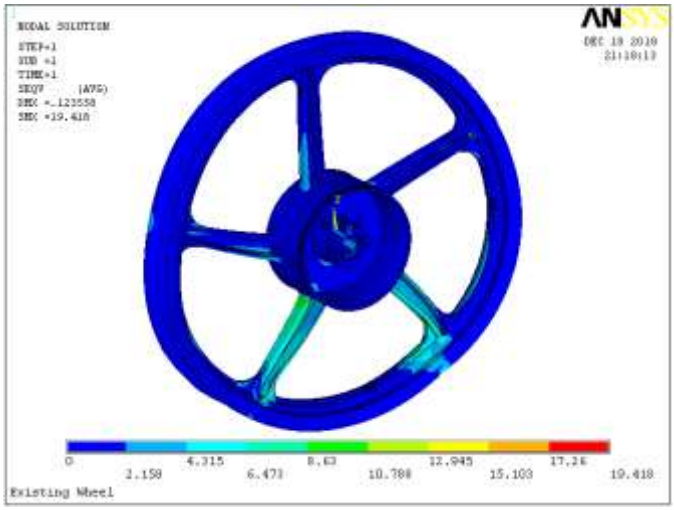


**Fig-9:** Equivalent Stresses in PEEK 90HMF20 Wheel at 250Kg 2452.5 N = 19.418Mpa

**Table-2:** Result Analysis at maximum loading

| Material | Deformation | | Equivalent Stress |
|---|---|---|---|
| Aluminium Alloy | Min | 0.032467mm | 22.008Mpa |
| | Max | 0.036525mm | 24.76Mpa |
| PEEK | Min | 0.066219mm | 20.579Mpa |
| | Max | 0.074496mm | 23.152Mpa |
| PEEK 30% glass fiber | Min | 0.059457mm | 17.689Mpa |
| | Max | 0.066889mm | 19.901Mpa |
| PEEK90HMF20 | Min | 0.109829 mm | 17.26MPa |
| | Max | 0.123558mm | 19.418MPa |

| | | | |
|---|---|---|---|
| PEEK90HMF40 | Min | 0..053907mm | 16.766MPa |
| | Max | 0.060645mm | 18.861MPa |

## 2.5 Analysis Data of PEEK Material

**Table-3:** Mechanical Properties of PEEK

| Mechanical property | Value | Unit |
|---|---|---|
| Density | 1320 | kg m^-3 |
| Coefficient of Thermal Expansion | 0.000046 | C^-1 |
| Specific Heat | 1470 × 106 | J kg^-1 C^-1 |
| Compressive Yield Strength | 118 × 106 | Pa |
| Tensile Ultimate Strength | 100 × 106 | Pa |
| Reference Temperature | 23 | C |
| Young's Modulus | 3.6 × 109 | Pa |
| Poisson's Ratio | 0.39 | |
| Bulk Modulus | 6.9608*1010 | Pa |
| Shear Modulus | 1.4 × 109 | Pa |

## 2.6 Static Analysis of PEEK-Material

(1) Maximum load of 250Kg (2452.5N)
(2) Fix the wheel at the bottom
(3) Apply load at the center
(4) Cylindrical support on outer hub area
(5) Compression only support on rim Circumference

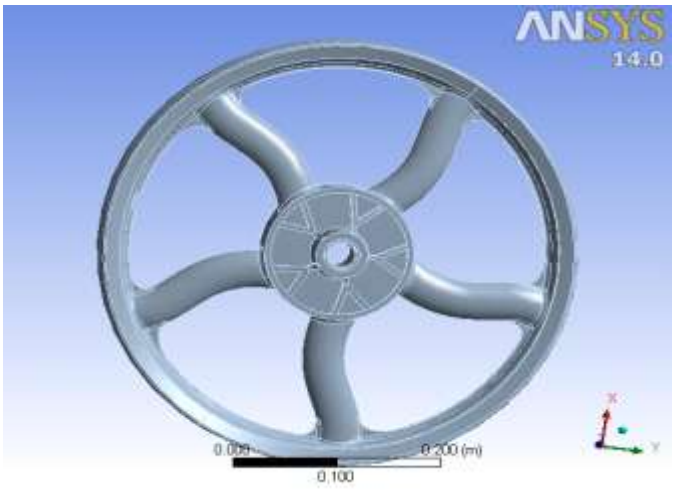



**Fig-10:** Modified 3D design of alloy wheel

**Table-4:** Design Parameters of Modified Wheel

| | |
|---|---|
| Rim outer diameter | 462mm |
| Rim width | 57mm |
| Hub diameter | 144mm |
| Spokes length | 121mm |
| Angle between two spokes | 76.510 |
| Spokes thickness | 44mm |

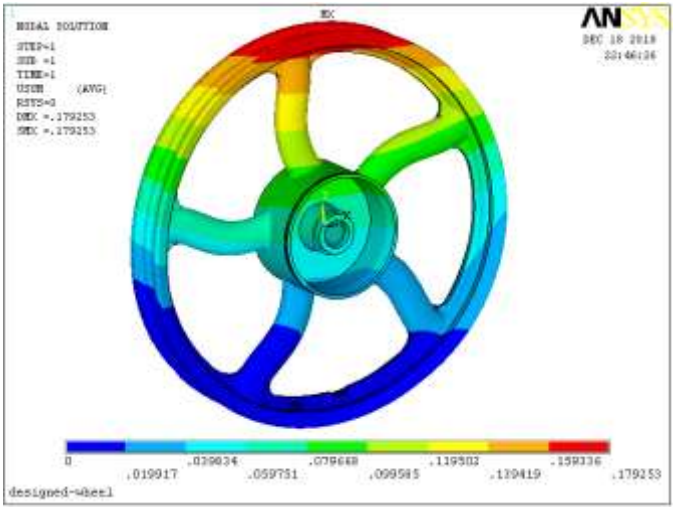



**Fig-11:** Total Deformation in Modified wheel of PEEK at Maximum load of 250Kg (2452.5N) = 0.179253 mm

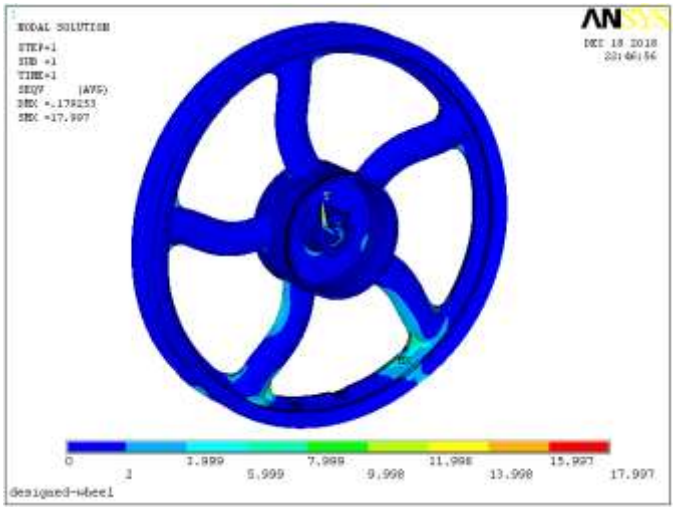



**Fig-12:** Equivalent Stress in Modified wheel of PEEK at Maximum load of 250Kg (2452.5N) = 17.997MPa

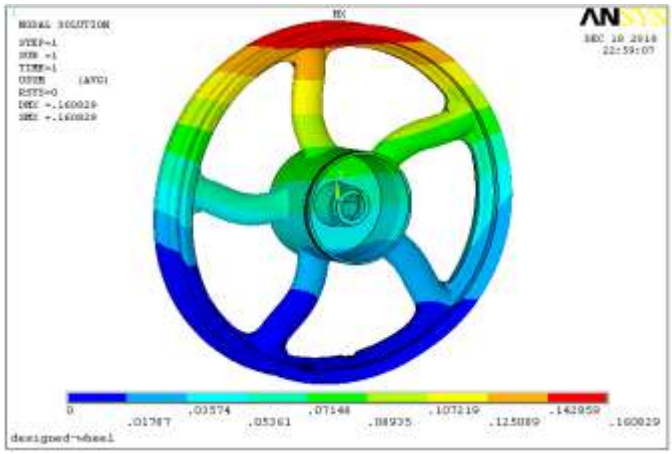


**Fig-13:** Total Deformation in PEEK30% Glass Fiber Modified Wheel at Maximum load of 250Kg (2452.5N) = 0.160829mm

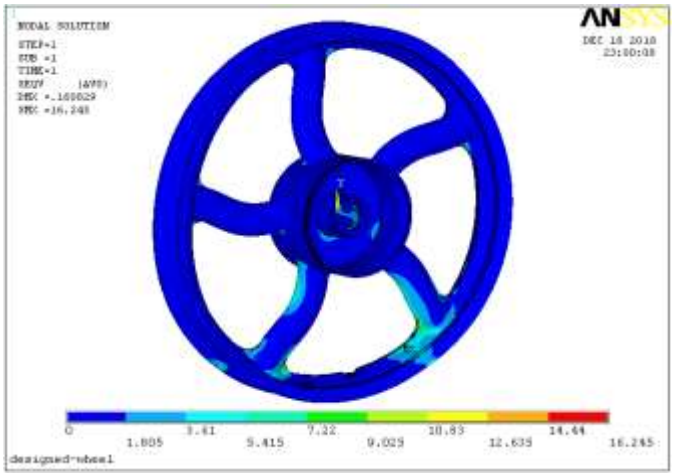


**Fig-14:** Equivalent Stress in PEEK30% Glass Fiber Modified Wheel at Maximum load of 250Kg (2452.5N) = 16.245MPa

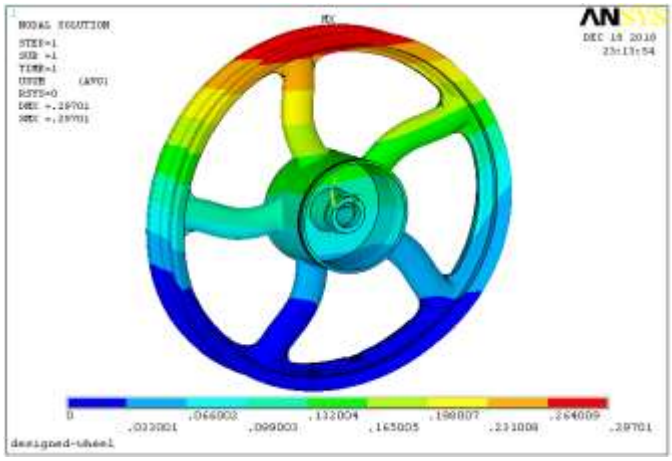


**Fig-15:** Total Deformation in PEEK90HMF20 Modified Wheel at Maximum load of 250Kg (2452.5N) = 0.29701mm

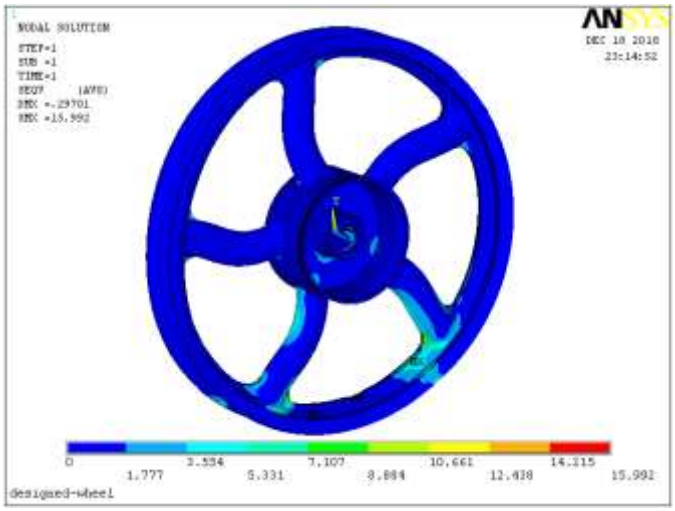


**Fig-16:** Equivalent Stress in PEEK90HMF20 Modified Wheel at Maximum load of 250Kg (2452.5N) = 15.992MPa

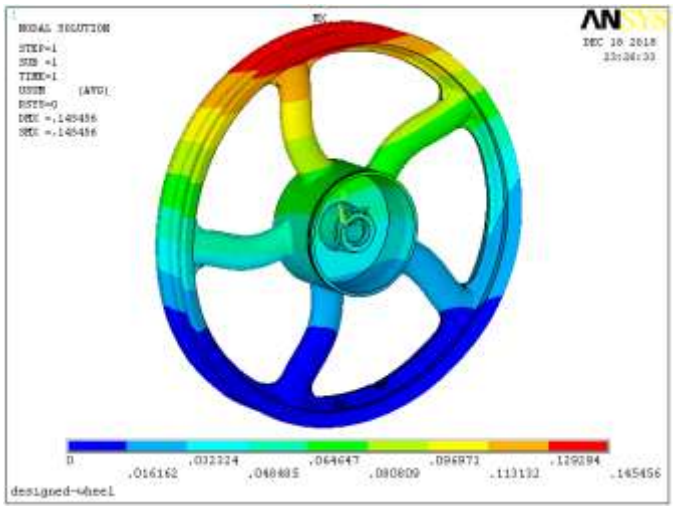


**Fig-17:** Total Deformation in PEEK90HMF40 Modified Wheel at Maximum load of250Kg (2452.5N) = 0.145456mm

**Table-5:** Result Analysis of different Material in Modified Design

| Material | Deformation | | Equivalent Stress |
|---|---|---|---|
| Aluminium Alloy | Min | 0.078027mm | 16.801MPa |
| | Max | 0.08778mm | 18.901MPa |
| PEEK | Min | 0.159336mm | 15.997MPa |
| | Max | 0.179253mm | 17.997MPa |
| PEEK 30% | Min | 0. mm | 14.44MPa |

| | | | |
|---|---|---|---|
| glass fiber | Max | 0.160829mm | 16.245MPa |
| PEEK90HMF20 | Min | 0. mm | 14.215MPa |
| | Max | 0.29701mm | 15.992MPa |
| PEEK90HMF40 | Min | 0. mm | 12.621MPa |
| | Max | 0.145456mm | 14.198MPa |

## 3. RESULT AND DISCUSSION

**Table-6:** Comparison Analysis Data of Different Material

| Material | | Analysis Data of Actual Wheel | | Analysis Data of Modified Wheel | |
|---|---|---|---|---|---|
| | | Total Deformation | Equivalent Stress | Total Deformation | Equivalent Stress |
| Aluminum Alloy | Minimum | 0.032467 mm | 22.008 MPa | 0.078027 mm | 16.801 MPa |
| | Maximum | 0.036525 mm | 24.76MPa | 0.08778 mm | 18.901 MPa |
| PEEK | Minimum | 0.066219 mm | 20.579 MPa | 0. mm | 15.997 MPa |
| | Maximum | 0.074496 mm | 23.152 MPa | 0.179253 mm | 17.997 MPa |
| PEEK With 30% Glass Fiber | Minimum | 0.059457 mm | 17.689 MPa | 0. mm | 14.44MPa |
| | Maximum | 0.066899 mm | 19.901 MPa | 0.160829 mm | 16.245 MPa |
| PEEK - 90HMF20 | Minimum | 0.109829 mm | 17.26MPa | 0. mm | 14.44MPa |
| | Maximum | 0.123558 mm | 19.418 MPa | 0.29701 mm | 15.992 MPa |
| PEEK - 90HMF40 | Minimum | 0.053907 mm | 16.766 MPa | 0. mm | 12.621 MPa |
| | Maximum | 0.060645 mm | 18.861 MPa | 0.145456 mm | 14.198 MPa |

**Table-7:** Comparison Data of Weight

| Material | Actual Wheel | Modified Wheel | Percentage Reduction in Weight |
|---|---|---|---|
| Aluminum Alloy | 5.300Kg | 4.956Kg | 6.5% |
| PEEK | 2.844Kg | 2.361Kg | 55.45% |
| PEEK30% Glass Fiber | 3.275Kg | 2.719Kg | 48.69% |
| PEEK90HMF20 | 2.952Kg | 2.451Kg | 53.75% |
| PEEK90HMF40 | 3.125Kg | 2.594Kg | 51.05% |

From the above tables it is clear that modified wheel mass reduction is maximum 55.45 % in PEEK, after this it is 53.75% in PEEK90HMF20, 51.05% in PEEK90HMF40, 48.69% in PEEK30% Glass Fiber and minimum reduction in Aluminum Alloy i.e. 6.5%

## 3. CONCLUSION

From the above tables & discussion it is clear that PEEK is Best material for the replace of Aluminium material.
Weight of Aluminum Wheel: 5.300 Kg
Cost of Aluminum Wheel: - 15-20K
Weight of Plastic Wheel: - 2.361Kg
Cost of Plastic Wheel: - 8-10K
Author gets the success to achieve the reduction in wheel rim weight & saving the cost of wheel rim (PEEK) material.

## ACKNOWLEDGEMENT

Author wants to say thanks to his guide for their support and guidance. Finally author wants to say thanks to all people who support him directly or indirectly during this work.

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