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# THE DESIGN AND ANALYSIS OF A MOTORCYCLE WHEEL BY USING ANSYS

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**ABSTRACT:-** *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. After designing of wheel, the material should be selected and to go through several analysis test on ANSYS software. By applying different loads in existing Aluminium alloy wheel and analyze the stresses, the material has been changed from Aluminium alloy to Polyether-ether ketone, Polyether-ether ketone with 30% glass fibre, PEEK90HMF20 and PEEK90HMF40 for the study. In the same design the materials has been changed one by one and applying different loads, and analyze the stresses. It is concluded that the existing design is not suitable for plastic material. Plastic material will deform at a maximum load of 2452.5N (250Kg). So change the design and the materials and analyze the stresses and finally conclude that Aluminium alloy can be replaced by plastic material.*

***Keywords:*** *UNIGRAPHICS, Degree of freedom, ANSYS, Polyether-ether ketone.*

## 1.INTRODUCTION

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.

After designing of wheel, the material should be selected and to go through several analysis test on ANSYS software. By applying different loads in existing Aluminium alloy wheel and analyze the stresses, the material has been changed from Aluminium alloy to Polyether-ether ketone, Polyether-ether ketone with 30% glass fibre, PEEK90hmf20 and PEEK90hmf40 for the study.

In the same design the materials has been changed one by one and applying different loads, and analyze the stresses. It is concluded that the existing design is not suitable for plastic material. Plastic material will deform at a maximum load of 2452.5N (250Kg). So change the design and the materials and analyze the stresses and finally conclude that Aluminium alloy can be replaced by plastic material.

### 1.1 Introduction of Design

A large number of wheel tests are required in designing and manufacturing of wheels to meet satisfactory requirement. Since the rims on which vehicle moves are the most vital element in a vehicle they must be designed carefully. Safety and economy are particularly of major concern when designing a mechanical structure so that the people could use them. The wheels are made of either steel or cast/forge aluminiumalloy. Automotive manufacturer have been developing safe, fuel efficient and light weight vehicular components to meet governmental regulation and industry standards.

The design is the creation of new and better machines and improving the existing ones. A latest or better design is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. From the study of existing ideas, a new idea has to be conceived.In the preparation of these drawings, care must be taken of the availability of resources i.e. money, men and material required for the successful completion of the new idea into an actual reality.

### 1.2 Classification of Design

**1.2.1-Adaptive design:** -In most cases, the designer's work is concerned with adaptation of existing design. The designer only makes minor alteration or modification in the existing design of the product.

**1.2.2-Development design:** - This type of design needs technical training and design ability in order to modify the existing design into a new one by adopting a new material or different method of manufacture.

**1.2.3-New design**:-This type of design needs lot of research technical ability and creative thinking. The design depending upon the method used may be classified as follow: -

**1.2.3.1 Rational design:** -This type of design depends upon empirical formulae of principle of mechanics.

**1.2.3.2Empirical design:** -This type of design depends upon empirical formulae based on the practice and past experience.

 

**1.2.3.3Industrial design**: - This type of design deals with the production aspects to manufacture any machine components in the industry.

**1.2.4 Modeling of Motorcycle wheel**

CAD Modeling is the base of any project. Finite Element software will consider shapes, whatever is made in CAD model. Solid modeling is the first step for doing any 3D analysis; it gives 3D physical picture for the products. FE models can easily be created from solid models by the process of meshing. CAD modeling software's are dedicated for the specialized job of 3D-modeling. Commercially available solid modeling packages are: AutoCAD, PRO-E, UNIGRAPHICS, and CATIA etc. CAD model designs with conventional and plastic materials of motorcycle wheel are created in UNIGRAPHICS NX6. UNIGRAPHICS contains special tools in generating typical surfaces, which are later converted into solid models. For modeling the aluminium alloy wheel, the dimensions of an existing wheel of a light commercial vehicle are chosen.

## 2. METHODOLOGY

**2.1.Finite Element Analysis**

Finite element analysis (FEA) is a tool used for the evaluation of system and structures. It is needed to analyze complex structures, whereas very simple ones, for example a beam can be analyzed using hand calculation. FEA is capable of performing parametric studies in which different geometries, material and loading conditions like thermal, structural and vibratory can be evaluated. A typical analysis evaluate the deflection and stresses which result and compares these against acceptable defined limits.The finite element analysis (finite element method) is a numerical technique for finding approximate solutions of partial differential equations as well as of integral equations. Thus the element equation cannot be solved alone to render the solution over each element. This task can only be performed by computer. It is noteworthy that as the structure is broken into a larger number of elements a greater number of simultaneously equations need to be solved. Thus typically results for more complex structure requires more computing power. Function of the FEA are a very accurate tool used for failure analysis purposes used to quantify design defects fatigue, buckling and code compliance can be used to distinguish between failure due to design, deficiencies material defects, fabrication error and abusive use provide quantified results previously based on metallurgical testing and excellent visual aids and animation easily understood.[20]

In the finite element method, a structure is broken down into many small simple blocks or elements. The behaviour of an individual element can be described with a relatively simple set of equations. This method of product design and testing is far superior to the manufacturing costs which would accrue if each sample was actually built and tested. The suitable design for the motorcycle alloy wheel weather to put 3-4 spokes or more for balancing while rider moving straight or cornering and slow motion or fast motion.

**2.2.DESIGN CHALLENGE**

The design of a motorcycle wheel contains several complexes and attempt has been made to meet the requirements of original equipment manufacturers (OEMs).The actual motorcycle wheel design is made by using NX 7.5, Author tried and ultimately succeeds with the drawing requirements and draws a complete design of motorcycle wheel. The developed design in is 6 degree of freedom (DOF) for characteristics and durability to fine tune the designs.

The whole design took about 4-5 weeks. The concept design of the component by using NX 7.5 reduces our lead time by 2-3 weeks as well as 6 DOF validation expenses.

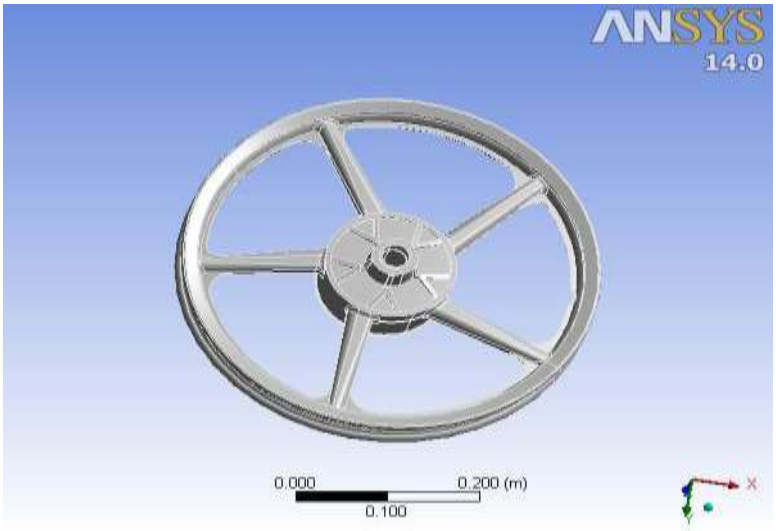


Fig-2.1 Three Dimensional design of alloy wheel

 

**Table 2.1 Design Parameters of AluminiumAlloy Wheel**

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

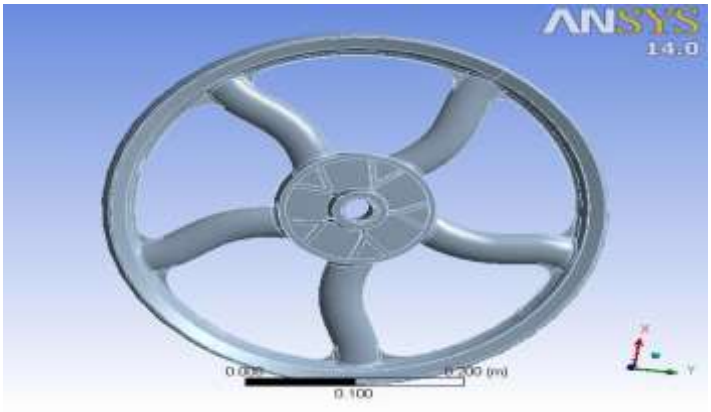


Fig-2.2 Modified 3D design of alloy wheel

Table 2.2 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 |

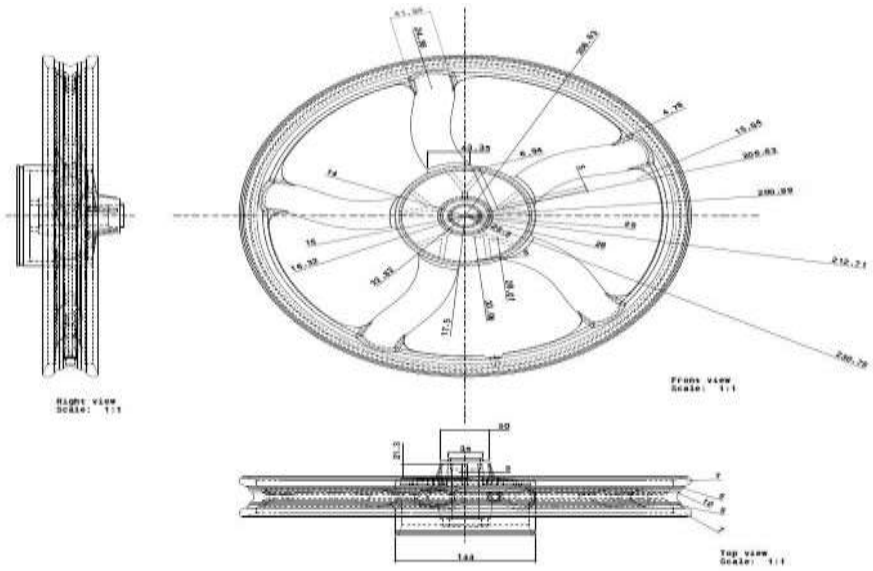

**Fig-2.3 Modified 2D design of alloy wheel**

 

### 2.3. MATERIAL APPOINTMENT

Several materials have been chosen which could meet the requirements of motorcycle wheel. By evaluating many of the components, the material finally appointed is Polyetheretherketone (PEEK), Polyetheretherketone with 30% glass fibre, PEEK90HMF20, PEEK90HMF40.

#### 2.3.1 PROPERTIES OF POLYETHERETHERKETONE (PEEK)

TABLE 2.3

| Temperature *C | Young's Modulus Pa | Poisson's Ratio | Bulk Modulus Pa | Density | Shear Modulus |
|---|---|---|---|---|---|
| 23 | 3.6*10^6 | 0.39 | 5.4*10^6 | 1320 kg m^-3 | 1.295*10^6 |

#### 2.3.2 PROPERTIES OF PEEK with 30% Glass fibre:

TABLE .2.4

| Temperature *C | Young's Modulus Pa | Poisson's Ratio | Bulk Modulus Pa | Density | Shear Modulus Pa |
|---|---|---|---|---|---|
| 23 | 4.06*10^6 | 0.45 | 1.3533*10^6 | 1520 kg m^-3 | 1.4*10^6 |

#### 2.3.3 PROPERTIES OF PEEK90HMF20

TABLE 2.5

| Temperature *C | Young's Modulus Pa | Poisson's Ratio | Bulk Modulus Pa | Density | Shear Modulus Pa |
|---|---|---|---|---|---|
| 23 | 2.2*10^6 | 0.455 | 8.2383*10^6 | 1370 kg m^-3 | 7.557*10^6 |

#### 2.3.4 PROPERTIES OF PEEK90HMF40

TABLE 2.6

| Temperature *C | Young's Modulus Pa | Poisson's Ratio | Bulk Modulus Pa | Density | Shear Modulus Pa |
|---|---|---|---|---|---|
| 23 | 4.5*10^6 | 0.48 | 3.75*10^6 | 1450 kg m^-3 | 1.5203*10^6 |

## 3. RESULTS

### 3.1 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

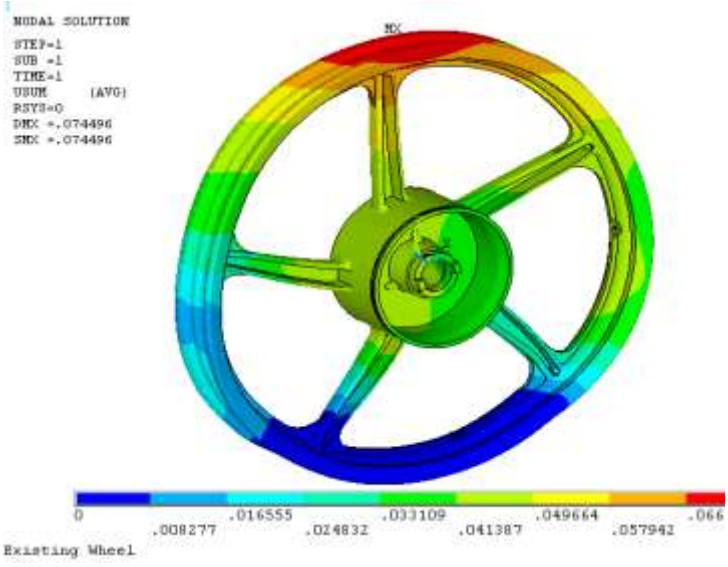


Figure 3.1 Total Deformation in Polyetheretherketone wheel at250Kg = 0.074496mm

 

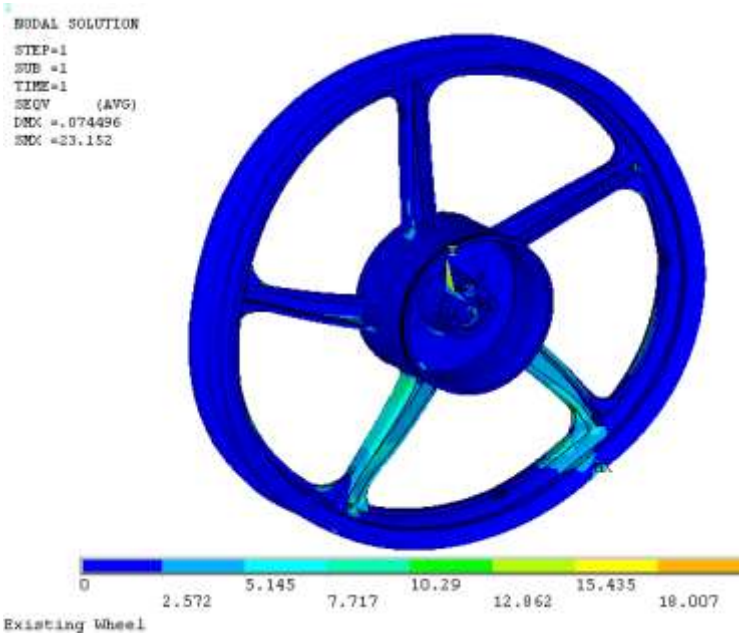


Figure 3.2 Equivalent Stress in Polyetheretherketone wheel at250Kg =23.152Mpa

TABLE 3.1RESULT ANALYSIS OF PEEK AT MAXIMUM LOADING:

| | Total Deformation | Equivalent Stress |
|---|---|---|
| Results | | |
| Minimum | 0.066219mm | 20.579Mpa |
| Maximum | 0.074496mm | 23.152Mpa |

**3.2 Analysis of PEEK with 30% Glass fibre**

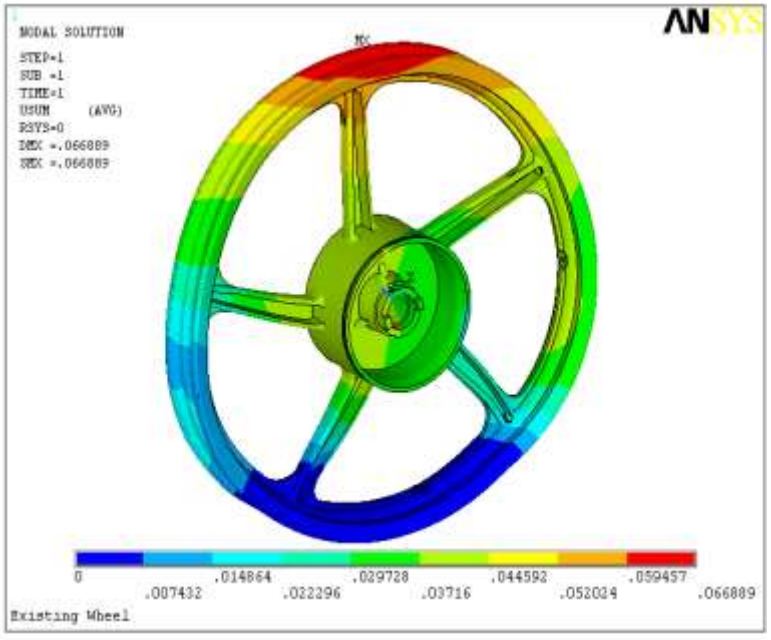


Figure 3.3 Total Deformation of PEEK 30% Glass Fibre Wheel at 250Kg(2452.50N) = 0.066889mm

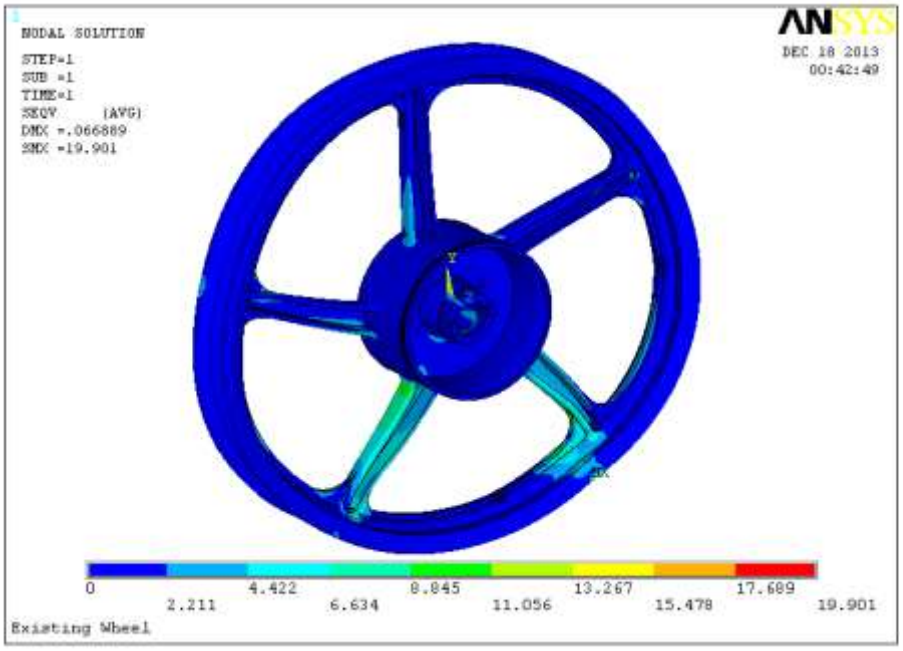


Figure 3.4 Equivalent Stress in PEEK 30% Glass Fibre Wheel at 250Kg(2452.5 N) = 19.901Mpa

**TABLE 3.2 Result analysis of peek 30% glass fibre at maximum loading:**

| | Total Deformation | Equivalent Stress |
|---|---|---|
| Results | | |
| Minimum | 0.059457mm | 17.689Mpa |
| Maximum | 0.066889mm | 19.901Mpa |

As shown in above fig. it indicated that maximum deformation occurred on theAluminium spokes of the wheel.

### 3.3. Result Analysis of PEEK90HMF20 Material

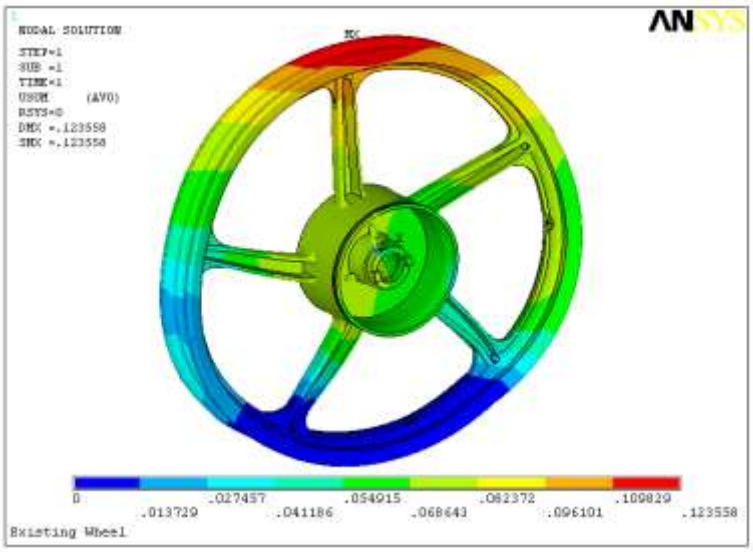


Figure 3.5 Total Deformation of PEEK90HMF20 Wheelat250Kg (2452.5N) = 0.123558mm

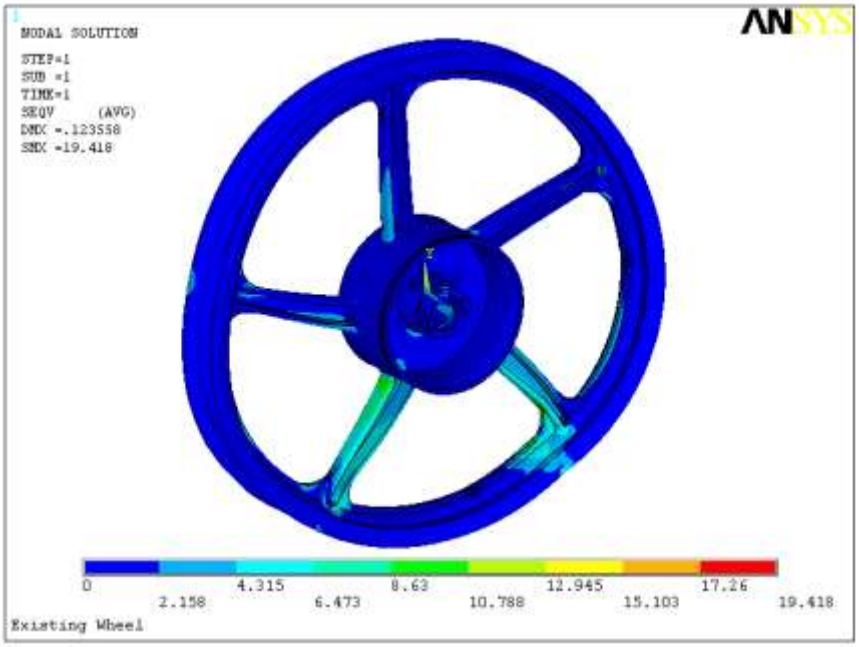


Figure 3.6 Equivalent Stresses in PEEK 90HMF20 Wheel at 250Kg 2452.5 N = 19.418Mpa

**TABLE 3.3 Result analysis of PEEK90HMF20 at maximum loading**:

| | Total Deformation | Equivalent Stress |
|---|---|---|
| Results | | |
| Minimum | 0.109829 mm | 17.26MPa |
| Maximum | 0.123558mm | 19.418MPa |

This material is also not suitable for the same design as the result shows wheel deformation occurred on the spokes of the wheel.

### 3.4Analysis Data of PEEK 90HMF40 Material

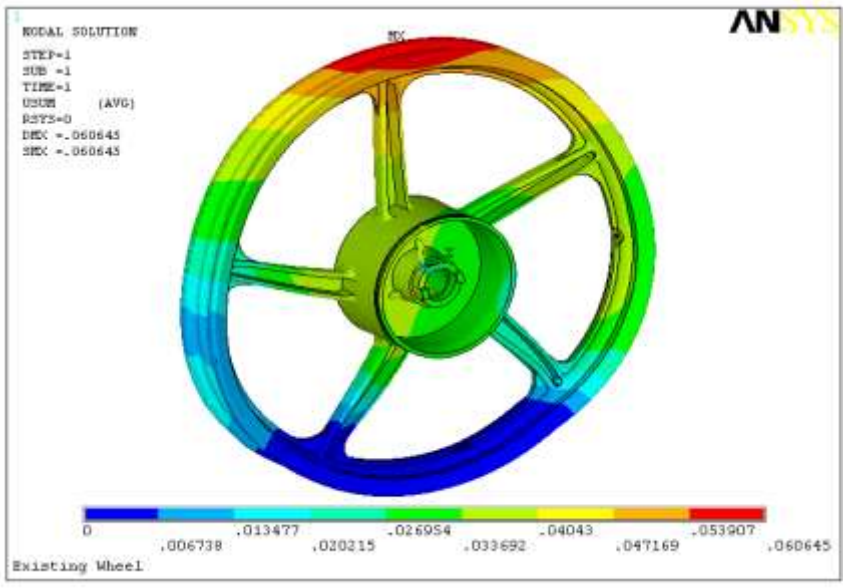


**Figure 3.7 Total Deformation of PEEK90HMF40 Wheel at 250Kg (2452.5N) = 0.060645mm**

 

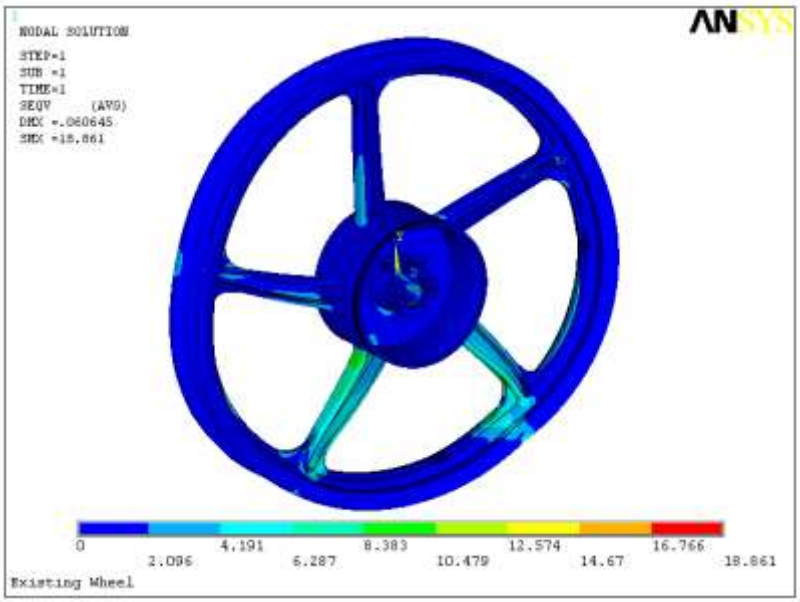


**Figure 3.8 Equivalent Stresses in PEEK 90HMF40 Wheel at 250Kg2452.5 N = 18.861Mpa**

**Table 3.4 Result Analysis of PEEK90HMF40 at maximum loading:**

| | **Total Deformation** | **Equivalent Stress** |
|---|---|---|
| **Results** | | |
| **Minimum** | 0..053907mm | 16.766MPa |
| **Maximum** | 0.060645mm | 18.861MPa |

PEEK90HMF40 material is also not suitable for the same design of Aluminium Wheel. Wheel deform at spokes, it cannot sustain under the load of 250Kg.
We will redesign the wheel for replacement of material from Aluminium alloy to Plastic material and to minimize the deformation, analyze one by one under the Maximum load of 250Kg.

## 4. DISCUSSION

### 4.1 Comparison Analysis Data of Different Material

**Table 4.1**

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

 

### 4.2 Comparison of Weight


**Figure4.1 Weight of Actual Wheel**

**Table 4.2 Comparison Data of Weight**

| Material | Actual Wheel | Modified Wheel | Percentage Reduction in Weight |
|---|---|---|---|
| Aluminium Alloy | 5.300Kg | 4.956Kg | 6.5% |
| PEEK | 2.844Kg | 2.361Kg | 55.45% |
| PEEK30% Glass Fibre | 3.275Kg | 2.719Kg | 48.69% |
| PEEK90HMF | 20 2.952Kg | 2.451Kg | 53.75% |
| PEEK90HMF40 | 3.125Kg | 2.594Kg | 51.05% |

### 4.3 Cost Estimation of Wheel

Weight of Aluminium Wheel: 5.300 Kg
Cost of Aluminium Wheel: - 15-20K
Weight of Plastic Wheel: - 2.361Kg
Cost of Plastic Wheel: - 8-10K

## 5. CONCLUSION

The project finally designs the motorcycle wheel for plastic material (Polyether etherketone, PEEK) which provides better strength and fatigue life to the wheel. Project also got succeed in minimizing the cost and weight of motorcycle wheel. When load decreases on the vehicle its efficiency increases, as the result shows Plastic wheel is lighter than Aluminium wheel it increases the overall efficiency of motorcycle.
The stress analysis of the component to define stresses on the assembly:
The fatigue life of the motorcycle wheel by using ANSYS 14.0 has been done successfully by which the various stress level have been tested which helps us to locate the point of stresses and shear of the motorcycle wheel, the loads and the structure's response are assumed to vary slowly with respect to time. A static structural load can be performed using the ANSYS 14.0 software. Future scope of the work As we all know that the economy of our country increases day by day it affects the cost of every product, the plastic wheel is cheap as compare to the aluminium wheel and also light in weight which increases the overall efficiency of the vehicle and decreases the overall cost of the vehicle.
Today 40-50% metal is replaced by plastic in vehicle, due to which the processing of plastic wheel is easy as compare to aluminium wheel so the production rate is also increases. In Future plastic wheel in motorcycle decreases the cost of vehicle and increases the overallefficiency of the motorcycle.

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