

Design and Analysis of Two Wheelers Wheel with the Replacement of Alluminium Alloy

Priya Udasi, Sanjay Kumbhare

Abstract: PEEK is an established material that is used in a variety of applications. PEEK has replaced metals like Aluminum and brass for cost and weight saving reasons as well as “metallic reactions”. It is also the one polymer that can meet the needs of more demanding applications where very high or low temperatures or chemical resistance are key operational parameters PEEK is an ideal replacement for Aluminum alloy as well as other types of metal tubing, and even glass for weight reduction, comparable strength/mass, chemical resistance, hardness, and low extractable. PEEK is particularly useful in the automobile industry for its weight. In an application where 2 grams can make a difference and weight is directly correlated to fuel cost, light weight PEEK is superior material matches aluminum in mechanical properties, and is more resistant to fluids. In this project work the entire wheel design of two wheeler was chosen and analyzed by applying different load and redesign the wheel again to minimize the deformation and material will be changed from aluminum to PEEK(polyether ether ketone)The following materials were chosen:-

Aluminum Alloy

PEEK(Polyether etherketone)

PEEK with 30% Glass fiber

PEEK-90 HMF 20

PEEK-90 HMF 40

Wheel design of two wheeler is made by using NX 7.5, and Analysis has been done by Ansys 13.0 software to determine the various stresses, strain and fatigue life of the wheel. The software has helped us really to achieve our goal.As the whole analysis is done by the means of software therefore result and observation are trustworthy and meet with our expectation.

Keywords: PEEK, FEM, UNIGRAPHICS, ANSYS 13.

I. 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), author has tried and ultimately succeeded 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 Aluminum alloy wheel and analyze the stresses, the material has been changed from Aluminum

alloy to Polyether-ether ketone, Polyether-ether ketone with 30% glass fiber, 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 Aluminum alloy can be replaced by plastic material.

II. EXPERIMENTAL

2.1 General Procedures in Design

Need or Aim
Synthesis (Mechanism)
Analysis of Forces
Material selection
Design of element
Modification
Detailed drawing
Production

2.2 Design Procedure

With the help of the measuring instrument -Vernier caliper, micrometer, radius Gauges and slip gauges, we have first taken all the dimension of the Aluminum alloy wheel. According to the dimension, profile of the component is drawn on the screen of the computer using UNIGRAPHICS (NX 7.5). After completing the draw the wheel model is then Import in the ANSYS 13 software. Before importing it is first save in IGES or STEP.

III. ANALYSIS FOR ALUMINUM ALLOY

3.1 Analysis Procedure

First of all we have taken the Aluminum alloy material composition i.e.

Revised Manuscript Received on 30 September 2014.

* Correspondence Author

Priya Udasi*, Rajiv Gandhi Proudयोगiki Vishwavidyalaya (RGPV), Bhopal, India.

Sanjay Kumbhare, Rajiv Gandhi Proudयोगiki Vishwavidyalaya (RGPV), Bhopal, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

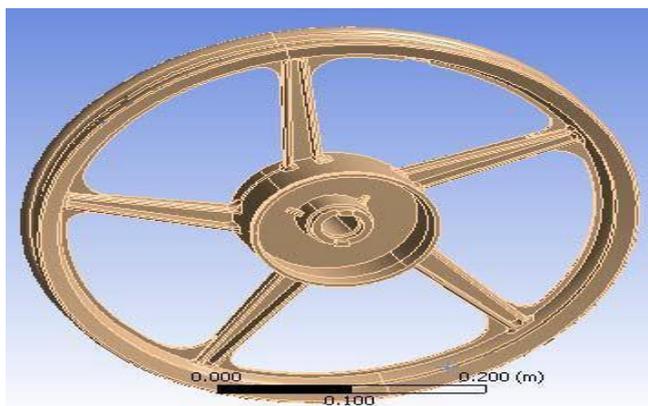
LM 13 Material composition of LM13 is Al-Si (BS: LM13) alloy was used as the matrix material. The alloy contains 11.00 wt.% Si, 1.00 wt.% Mg, 1.50 wt.% Ni, 1.00 wt.% Cu, 0.80 wt.% Fe, 0.50 wt.% Mn and balance was Al. LM13-10 wt.% SiCp composite

Design and Analysis of Aluminum Alloy Wheel using PEEK Material

was prepared by dispersing hard particles in Aluminum matrix using stir-casting technique. [4] From the design data book –Mechanical property.

Mechanical property	Value	Unit
Density	2770	kg m ⁻³
Coefficient of Thermal Expansion	0.000023	C ⁻¹
Specific Heat	875	Jkg ⁻¹ C ⁻¹
Compressive Yield Strength	2800*10 ⁵	Pa
Tensile Ultimate Strength	3100	Pa
Reference Temperature	22	C
Young's Modulus	7.1 *10 ¹⁰	Pa
Poisson's Ratio	0.33	
Bulk Modulus	6.9608*10 ¹⁰	Pa
Shear Modulus	2.6692*10 ¹⁰	Pa
Relative Permeability	1	

And these mechanical properties are defined into the material list of ANSYS software data list. For the Static analysis component drawing is call in ANSYS software and then mechanical property is define on Aluminium alloy wheel.



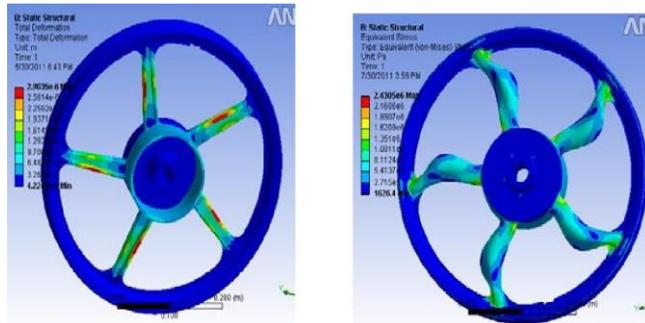
IV. STATIC ANALYSIS

4.1 Aluminium Alloy wheel

(A)Under

- (1) Maximum Inflation pressure on rim circumference 2100 KPa
- (2) Hub fix
- (3) Rotation velocity in Z –direction –200 rad/sec
- (4) Cylindrical support on outer hub area
- (5) Compression only support on rim circumference

V. ANALYSIS RESULT



Total Deformation

Equivalent Stress

VI. RESULT AND DISCUSSION

Total Deformation	Equivalent Stress	Results
Minimum	4.2245*10 ⁻⁹ m	1626.4 Pa
Maximum	2.9035*10 ⁻⁶ m	2.2305*10 ⁶ Pa

From the above fig. it does not deform i.e. it can sustain under Max. Inflation Pressure on wheel 2100 KPa.

VII. ANALYSIS DATA OF PEEK MATERIAL

7.1 Analysis Procedure

Under same maximum. Inflation pressure on wheel 2100 KPa, Hub fix and Rotation velocity in Z –direction –200 rad/sec and after defining the mechanical property of different grade of PEEK polymer on wheel if wheel does not deform the we can easily replace Aluminium alloy wheel with PEEK polymer wheel .From the journal Published online by the VBRI press in 2011 _ received: 6 Dec 2010, Revised: 12 Jan 2011 and Accepted: 16 Jan 2011 _by

Mechanical property	Value	Unit
Density	1320	kg m ⁻³
Coefficient of Thermal Expansion	46.8 × 10 ⁻⁶	C ⁻¹
Specific Heat	1470 × 10 ⁶	J kg ⁻¹ C ⁻¹
Compressive Yield Strength	118 × 10 ⁶	Pa
Tensile Ultimate Strength	100 × 10 ⁶	Pa
Reference Temperature	22	C
Young's Modulus	3.6 × 10 ⁹	Pa
Poisson's Ratio	0.39	
Bulk Modulus	6.9608*10 ¹⁰	Pa
Shear Modulus	1.4 × 10 ⁹	Pa

NituBhatnagar, SangeetaJha, Shantanu Bhowmik. [10]

Design and Analysis of Aluminum Alloy Wheel using PEEK Material

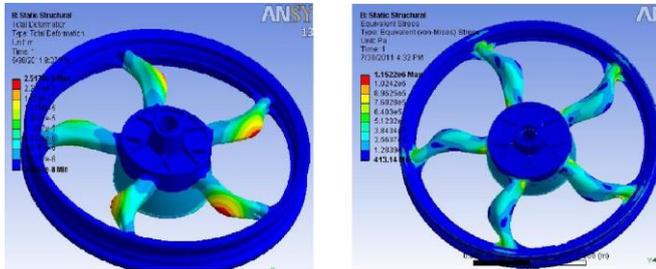
And different properties are defined into the material list of ANSYS software data list. For the Static analysis same component drawing is call in ANSYS software and then material is define on wheel.



**Static Analysis
PEEK-Material
(B) Under**

- (1) Maximum Inflation pressure on rim circumference 2100 KPa
- (2) Hub fix
- (3) Rotation velocity in Z –direction 200 rad/sec
- (4) Cylindrical support on outer hub area
- (5) Compression only support on rim Circumference

VIII. ANALYSIS RESULT



Total Deformation

Equivalent Stress

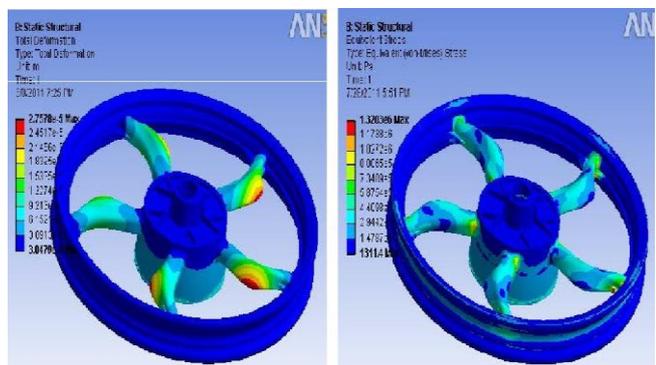
IX. RESULT AND DISCUSSION

	Total Deformation	Equivalent Stress
Results		
Minimum	3.1092*10 ⁻⁸ m	413.14 Pa
Maximum	2.5178*10 ⁻⁵ m	1.1522 *10 ⁶ Pa

As shown in above fig. it indicated that maximum deformation occurred on the aluminium spokes of the wheel i.e it does not sustain under Max. Inflation pressure on wheel 2100 KPa.

X. ANALYSIS DATA OF PEEK WITH 30% GLASS FIBER MATERIAL

10.1 Analysis Result



Total Deformation

Equivalent Stress

Design and Analysis of Aluminum Alloy Wheel using PEEK Material

XI. RESULT AND DISCUSSION

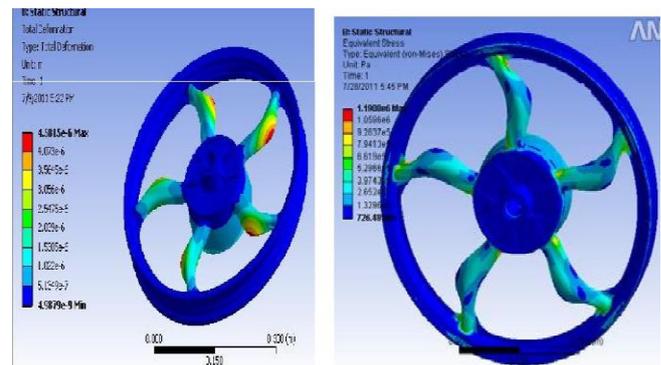
	Total Deformation	Equivalent Stress
Results		
Minimum	3.0479*10 ⁻⁸ m	1311.4 Pa
Maximum	2.7578*10 ⁻⁵ m	1.3203*10 ⁶ Pa

As shown in above fig. it indicated that maximum deformation occurred on the aluminium spokes of the wheel i.e. it does not sustain under Max. Inflation pressure on wheel 2100 KPa.

XII. ANALYSIS DATA OF PEEK 90HMF20 MATERIAL

Mechanical property	Value	Unit
Density	1370	kg m ⁻³
Tensile Yield Strength	2.8*10 ⁸	Pa
Compressive Yield Strength	2.7*10 ⁸	Pa
Tensile Ultimate Strength	1.*10 ⁸	Pa
Young's Modulus	2.2*10 ¹⁰	Pa
Poisson's Ratio	0.4556	
Bulk Modulus	8.2583*10 ¹⁰	Pa
Shear Modulus	7.557*10 ⁹	Pa

XIII. ANALYSIS RESULT



Total Deformation

Equivalent Stress

XIV. RESULT AND DISCUSSION

	Total Deformation	Equivalent Stress
Results		
Minimum	4.9879*10 ⁻⁹ m	726.48 Pa
Maximum	4.5815*10 ⁻⁶ m	1.1908*10 ⁶ Pa

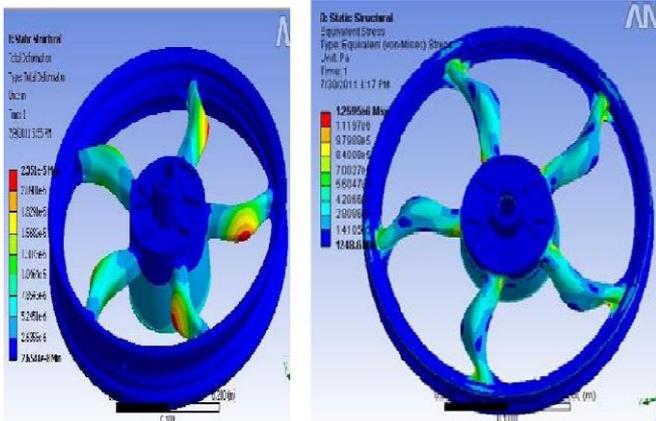
As shown in above fig. it indicated that maximum deformation occurred on the aluminium spokes of the wheel i.e it does not sustain under Max. Inflation pressure on wheel 2100 KPa.

XV. ANALYSIS DATA OF PEEK 90HMF40 MATERIAL

Mechanical property	Value	Unit
Density	1450	kg m ⁻³
Tensile Yield Strength	3.3*10 ⁹	Pa
Compressive Yield Strength	3.1*10 ⁸	Pa
Tensile Ultimate Strength	1.*10 ⁸	Pa

Young's Modulus	4.5×10^9	Pa
Poisson's Ratio	0.48	
Bulk Modulus	3.75×10^{10}	Pa
Shear Modulus	1.5203×10^9	Pa

XVI. ANALYSIS RESULT



Total Deformation

Equivalent Stress

Design and Analysis of Aluminum Alloy Wheel using PEEK Material

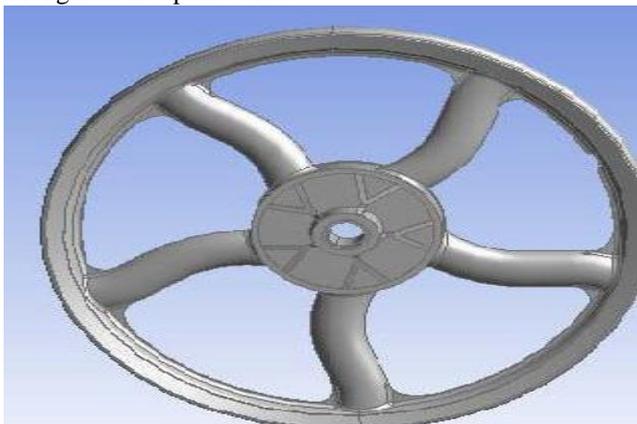
XVII. RESULT AND DISCUSSION

	Total Deformation	Equivalent Stress
Results		
Minimum	2.6544×10^{-8} m	1248.6 Pa
Maximum	2.351×10^{-5} m	1.2595×10^6 Pa

As shown in above fig. it indicated that maximum deformation occurred on the aluminium spokes of the wheel i.e it does not sustain under Max. Inflation pressure on wheel 2100 KPa.

XVIII. REDESIGN THE ALLOY WHEEL

So to minimize this deformation, we have change the shape of the spokes section according to required for PEEK alloy wheel as shown in below fig. in order to give the maximum strength at the spokes area.

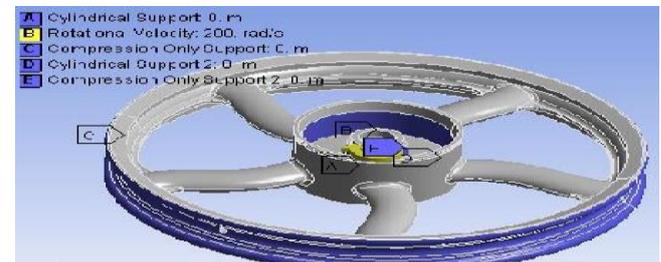


And the same procedure is repeated for analysis of change model as show in above figure. under same condition.

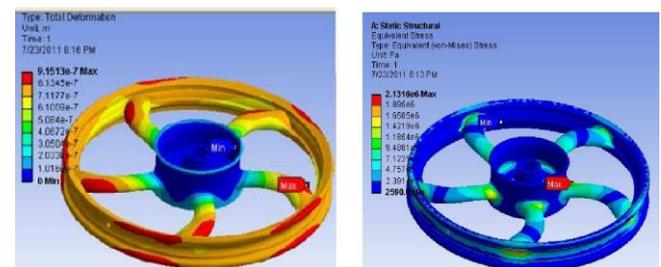
Static Analysis

(C)Under

- (1) Maximum Inflation pressure on rim circumference 2100 KPa
 - (2) Hub fix
 - (3) Rotation velocity in Z –direction 200 rad/sec
 - (4) Cylindrical support on outer hub area
 - (5) Compression only support on rim circumference
- Compression only support on inside circumference of hub area**



Analysis Result of PEEK material



Total Deformation

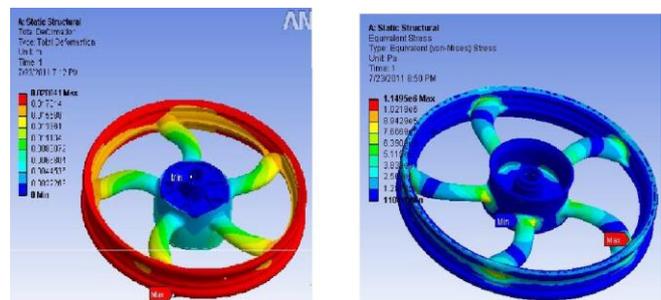
Equivalent Stress

Result

	Total Deformation	Equivalent Stress
Results		
Minimum	0. m	2590.3 Pa
Maximum	9.1513×10^{-7} m	2.1316×10^6 Pa

Design and Analysis of Aluminum Alloy Wheel using PEEK Material

XIX. ANALYSIS RESULT OF PEEK WITH 30% GLASS FIBER



Total Deformation

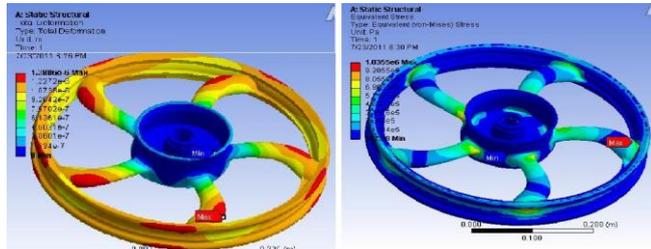
Equivalent Stress



Result

	Total Deformation	Equivalent Stress
Results		
Minimum	0. m	1104.1 Pa
Maximum	8.3276*10 ⁻⁶ m	1.1495*10 ⁶ Pa

XX. ANALYSIS RESULT OF PEEK - 90HMF20



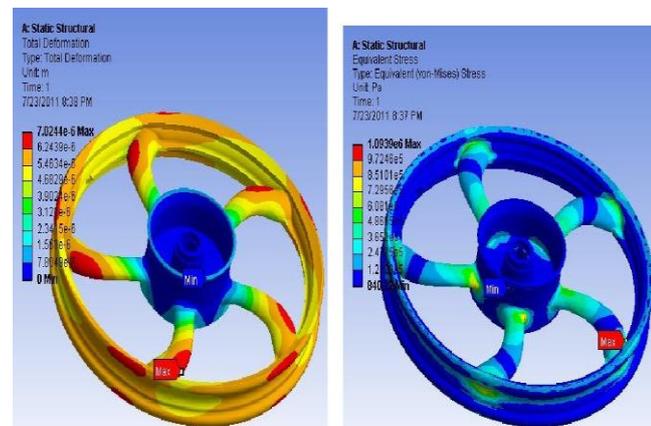
Total Deformation

Equivalent Stress

Result

	Total Deformation	Equivalent Stress
Results		
Minimum	0. m	887.08 Pa
Maximum	1.3806*10 ⁻⁶ m	1.0355*10 ⁶ Pa

XXI. ANALYSIS RESULT OF PEEK - 90HMF40



Result

XXII. COMPARISON ANALYSIS DATA OF DIFFERENT MATERIAL

Material		Analysis Data Before		Analysis Data After	
		Redesign of Alloy Wheel		Redesign of Alloy Wheel	
		Total Deformation	Equivalent Stress	Total Deformation	Equivalent Stress
Aluminum Alloy	Minimum	4.2245*10 ⁻⁹ m	1626.4 Pa	0. m	2126.4 Pa
	Maximum	2.9035*10 ⁻⁶ m	2.2305*10 ⁶ Pa	1.804*10 ⁻⁶ m	2.8711*10 ⁶ Pa
PEEK	Minimum	3.1092*10 ⁻⁸ m	413.14 Pa	0. m	2590.3 Pa
	Maximum	2.5178*10 ⁻⁵ m	1.1522 *10 ⁶ Pa	9.1513*10 ⁻⁷ m	2.1316*10 ⁶ Pa
PEEK With	Minimum	3.0479*10 ⁻⁸ m	1311.4 Pa	0. m	1104.1 Pa

Design and Analysis of Aluminum Alloy Wheel using PEEK Material

30% Glass Fiber	Maximum	2.7578*10 ⁻⁵ m	1.3203*10 ⁶ Pa	8.3276*10 ⁻⁶ m	1.1495*10 ⁶ Pa
	Minimum	4.9879*10 ⁻⁹ m	726.48 Pa	0. m	887.08 Pa
PEEK - 90HMF 20	Maximum	4.5815*10 ⁻⁶ m	1.1908*10 ⁶ Pa	1.3806*10 ⁻⁶ m	1.0355*10 ⁶ Pa
	Minimum	2.6544*10 ⁻⁸ m	1248.6 Pa	0. m	840.22 Pa
PEEK - 90HMF 40	Maximum	2.351*10 ⁻⁵ m	1.2595*10 ⁶ Pa	7.0244*10 ⁻⁶ m	1.0939*10 ⁶ Pa

XXIII. CONCLUSION

From the above table it is clear that PEEK 90HMF20 is best material for the replace ofAluminium material.

ACKNOWLEDGEMENT

It is immense pleasure to express my deepest sense of gratitude and sincere thanks to my highly respected and esteemed, Mr. Sanjay Kumbhare Assistant Prof. RGPV, Bhopal to complete this paper. I would like to express thanks to my parents Shri. Chandra Kumar Udasi and Smt. Reshma Udasi without their encouragement love and blessings I would not have reached this level manuscript.

REFERENCES

- Ch. P.V. Ravi Kumar, Prof. R. Satya Meher. "Topology Optimization of Aluminum Alloy Wheel". International Journal of Modern Engineering Research, ISSN: 2249-6645, Vol-3 May-June 2013 pp-1548-1553.
- Reference Book of Machine Design. R.S.Khurmi.
- Ruzanna Nadia Binti Nisah, Finite element Analysis of a Motorcycle Alloy Wheel. Generated by Foxit Creator.
- C.Bosi, G.L Garagnani, R.Tovo (2011). Fatigue Properties of A Cast Aluminum Alloy for Rims of Wheels. International Journal of Metallurgical Science. vol. No.3 p. 660-667.
- N. Satyanarayan and Ch. Sambaiah (2012). Fatigue Analysis of Aluminum Alloy Wheel Under Radial Load. . International Journal of Mechanical and Industrial Engineering, ISSN No. 2231-6477, Vol-2, Issue-1, 2012.
- Alloy Wheel from Wikipedia, the free encyclopedia.
- Introduction to Plastic Material.
- Zeus Technical Whitepaper copyright@2006 Zeus Industrial Products.Inc.
- Victrax High Performance Polymers, Victrax PEEK90HMF20
- Victrax High Performance Polymers, Victrax PEEK90HMF40
- N.Satyanarayan, Ch. Sambaiah "Fatigue Analysis of Aluminum Alloy Wheel Under Radial Load".
- S.K Biswas, W.A Knight, Perform design for closed die forging: experimental basis for computer aided design Int. J. Mach Tool Des.Res 15 (1975) 179-193.
- Akgerman, T. Altan, Recent development in computer-aided design of forging process, SME Technical Paper, 1972, pp. 72-110.
- Liangmo Wang, Yufa Chen –Chenzhi Wang- Qingzheng Wang. Fatigue Life Analysis of Aluminum Wheels by Simulation of Rotary Fatigue Test. Journal of Mechanical Engineering 57 (2011) 31-39.
- From Wikipedia, The free encyclopedia. Alloy Wheels
- Ticona on the web: www.ticona.com
- PlasticsEngineeredProductDesign_ Dominick Rosato and Donald Rosato_ ELSEVIER
- PLASTICS ENGINEERING_ Third Edition_ R.J. Crawford, BSc, PhD, DSc, FEng, FIMechE, FIM_Butterworth H einemann.