International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 2, No. 3, July 2013

Research Paper

MODELLING AND ANALYSIS OF A MOTORCYCLE WHEEL RIM

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Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium Metals or sometimes a mixture of both. Alloy wheels differ from steel wheels because Of their lighter weight, which improves the driving and handling of the motorcycle. Alloy wheels made up of composite materials will reduce the unstrung weight of a vehicle compared to one fitted with standard aluminum alloy wheels. The benefit of reduced unstrung weight is more precise handling and reduction in fuel consumption. Alloy is an excellent conductor of heat, improving heat dissipation from the Brakes, reducing the risk of brake failure. At present Motor cycle wheels are made of Aluminum Alloys. In this project, Aluminum alloy are comparing with other Alloy and composite materials. In this project a parametric model is designed for Alloy wheel used in two wheelers from existing model. Wheel rim is that part of an automotive where it undergoes static and fatigue loads because it traverses on a lot of roads. This develops heavy stresses in the rim and thus it is necessary to determine the critical stress point and shear stress. For modal analysis, the model has to be built, loads are applied and solutions are obtained. Motorcycle model is Bajaj pulsar 150 cc.

Keywords: Motorcycle alloy wheel, Static-structural analysis, Frequency analysis, Model analysis, Aluminum alloy, Magnesium alloy, Composite materials

INTRODUCTION

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation while supporting a load (mass), or performing labor in machines. Common examples are found in transport applications. A wheel, together with an axle overcomes friction by facilitating motion by rolling. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force. More generally the term is also used for other circular objects that rotate or turn, such as a ship's wheel, steering wheel and flywheel.

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TYPES OF WHEELS

There are so many types of wheels still in use in the automobile industry today. They vary significantly in size, shape, and materials used, but all follow the same basic principles.

Wire Spoke Wheel

Wire spoke wheel is a structural where the outside edge part of the wheel (rim) and the axle mounting part are connected by numerous wires called spokes. Today's vehicles with their high horsepower have made this type of wheel construction obsolete. This type of wheel is still used on classic vehicles. Light alloy wheels have developed in recent years, a design to emphasize this spoke effect to satisfy users fashion requirements.

Steel Disc Wheel

This is a rim which processes the steel-made rim and the wheel into one by welding, and it is used mainly for mopeds vehicle especially original equipment tires.

Light Alloy Wheel

These wheels based on the use of light metals such as aluminum and magnesium has become popular in the market. These wheels rapidly become popular for the original equipment vehicle in Europe in 1960's and for the replacement tire in United States in 1970's. The features of each light alloy wheel are explained as below:

Aluminium Alloy Wheel

Aluminium is a metal with features of excellent lightness, thermal conductivity, corrosion resistance, characteristics of casting, low temperature, machine processing and recycling, etc. This metals main advantage is reduced weight, high accuracy and design choices of the wheel. This metal is useful for energy conservation because it is possible to re-cycle aluminum easily.

Magnesium Alloy Wheel

Magnesium is about 30% lighter than aluminum, and also, excellent as for size stability and impact resistance. Recently, the technology for casting and forging is improved, and the corrosion resistance of magnesium is also improving. This material is receiving special attention due to the renewed interest in energy conservation.

Composite Material Wheel

The composite materials wheel, is different from the light alloy wheel, and it (Generally, it is thermoplastic resin which contains the glass fiber reinforcement material) is developed mainly for low weight. Again the second composite material, i.e., Carbon fiber which is been used now a days. This material is also having similar properties of thermoplastic resin. The use of this material is restricted to only sports vehicles because of their high cost of manufacturing process.

SPECIFICATION OF THE PROBLEM

Aluminum alloy are comparing with other Alloy. In this project a parametric model is designed for Alloy wheel used in two wheeler by collecting data from reverse engineering process from existing model. Design is evaluated by analyzing the model by taking the constraints as ultimate stresses and variables as two different alloy materials and different loads and goals as maximum outer diameter of the wheel and fitting accessories areas of bolt.

COMPOSITE MATERIALS

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Composites are combinations of two Materials in which one of the material is called the "matrix phase" is in the form of fibers, sheets, or particles and is embedded in the other material called the "reinforcing phase". Another unique characteristic of many fiber rein forced composites is their high internal damping capacity. This leads to better vibration energy absorption within the material land results in reduced transmission of noise to neighboring structures. Many composite materials offer a combination of strength and modulus that are either comparable to or better than any traditional metallic metals.

Because of their low specific gravities, the strength to weight-ratio and modulus to weight ratios of these composite materials are markedly superior to those of metallic materials. The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates are excellent. For these reasons, fiber composite have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries.

SPECIFICATION OF EXISTING ALLOY WHEEL

Table 1 shows the specifications of a Motorcycle Bajaj pulsar. The typical chemical composition of the material for:

- Aluminum alloy (%) is Copper-0.25, maganese-0.35, silicon-6.5 to 7.5, iron-0.6%, zinc-0.35, others-0.05, Aluminum- 87 to 100.
- Magnesium alloy (%) is maganese-0.6 to 1.4, calcium-0.04, silicon-0.1, copper-0.05, Nickel-0.005, iron-0.005, magnisium-85 to 100.
- Carbon fiber is a material consisting of fibers about 5-10 μm in diameter and composed mostly of carbon atoms. The earliest carbon fibers were produced by thermal decomposition of rayon precursor materials. The starting material is now polyacrylonitrile.
- The thermoplastic resins used as composite matrices such as polyether etherketone, polyphenylene sulfide, and polyetherimide.

Table 1: Specification of Existing Alloy Wheel

1.	Diameter of Wheel Rim	431.8 mm
2.	Perimeter of Wheel Rim	2711.704 mm
3.	Weight of Existing Alloy Wheel	1.98 kg

STRUCTURAL ANALYSIS OF ALLOY WHEEL

Static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis, however, includes steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes) Table 1.

Loads in a Structural Analysis

Static analysis is used to determine the displacements, stresses, strains, and forces

in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed that is the loads and the structure's response are assumed to vary. Slowly with respect to time. The kinds of loading that can be applied in a static analysis include:

Table 2: Static Analysis

	Normal Stress (N/mm^2)	
	Min.	Max.
Aluminum	–171.52	104.59
Magnesium	–168.00	180.90
Carbon Fiber	–171.40	140.00
Thermoplastic Resin	–170.73	144.40

Table 3: Static Analysis

	Equivalent Stress (N/mm^2)	
	Min.	Max.
Aluminum	0.0004614	259.0
Magnesium	0.1171000	332.0
Carbon Fiber	0.0004420	259.2
Thermoplastic Resin	0.0005010	263.0

Table 4: Static Analysis

	Stress Ratio	
	Min.	Max.
Aluminum	1.64×10^{-6}	0.9200
Magnesium	0.00088	1.7372
Carbon Fiber	9.21×10^{-8}	0.0540
Thermoplastic Resin	8.79×10^{-8}	0.0462

Table 5: Statistic Analysis

	Weight (gm)	Volume (m^3)
Aluminum	1976	7.136×10^{-4}
Magnesium	1284	7.136×10^{-4}
Carbon Fiber	1213	7.136×10^{-4}
Thermoplastic Resin	1070	7.136×10^{-4}

FATIQUE ANALYSIS OF ALLOY WHEEL

If you have been in an accident or purchased a bike with unknown history it is possible that your motorcycle wheel could be out of true. The wheel might seem to oscillate laterally (side to side) or appear to move up and down (out of round). Motorcycle rims can be casually inspected by supporting the bike on the centre stand or other stand and spinning them while viewing side on or edgewise. The cyclic stresses or strains give origin to damage accumulation until it develops into a crack that finally leads to failure of the component.

Table 6: Fatigue Analysis

	Shear Stress (N/mm^2)	
	Min.	Max.
Aluminum	–89.80	82.90
Magnesium	–99.40	82.01
Carbon Fiber	–89.52	82.90
Thermoplastic Resin	–89.52	82.69

Table 7: Frequency Analysis

	Total Deformation (m)	
	Min.	Max.
Aluminum	0	0.001250
Magnesium	7.49×10^{-7}	0.002510
Carbon Fiber	0	0.002223
Thermoplastic Resin	0	0.001960

CONCLUSION

A fatigue lifetime prediction method of alloy wheels was proposed to ensure their durability at the initial design stage. To simulate the rotary

test, static load FEM model was built using ANSYS v11. Therefore, the finite element model can achieve results consistent with that obtained from the actual static load test. The nominal stress method was used to predict the fatigue life of alloy wheels. In the nominal stress method, the fatigue life of alloy wheels was predicted by using alloy wheel S-N curve and equivalent stress. Alloy wheel rotary fatigue bench test was conducted. These results indicate that the fatigue life simulation can predict weakness area and is useful for improving alloy wheel. These results also indicate that integrating FEA and nominal stress method is a good and efficient method to predict alloy wheels fatigue life. For all comparing the three materials of stress, displacement, total deformation, weight, and cost of material we suggest that the thermoplastic resin is best material for wheel rim but due to their high manufacturing cost presently we are not using this material. Thermoplastic resin have only really been used in high end sports cars And the research is going on their manufacturing process to make their way into traditional vehicles.

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APPENDIX

Figure 1: Total Deformation of Aluminum

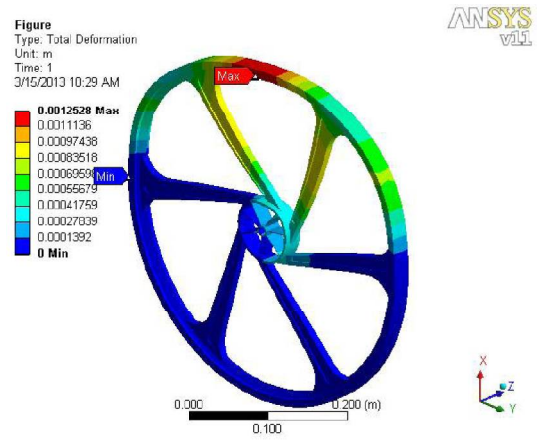


Figure 2: Equivalent Stress of Aluminum

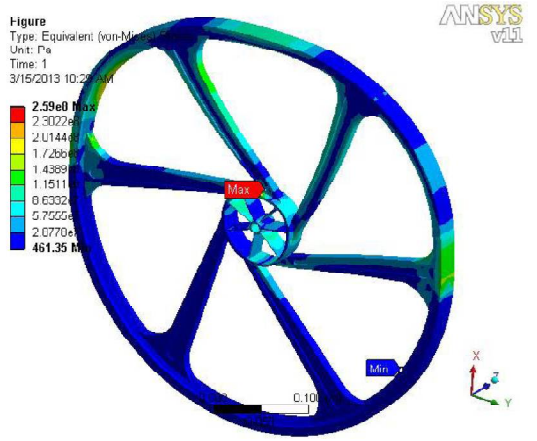


Figure 3: Normal Stress of Aluminum

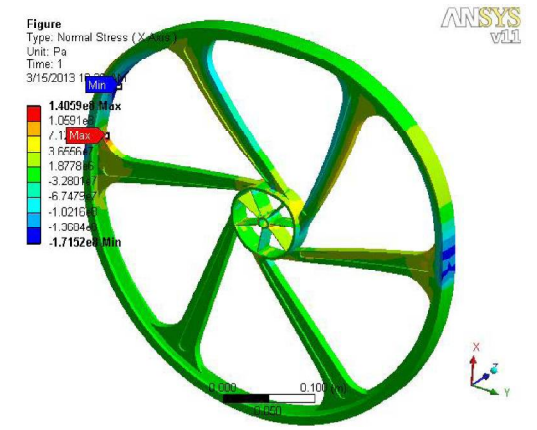


Figure 4: Shear Stress of Aluminum

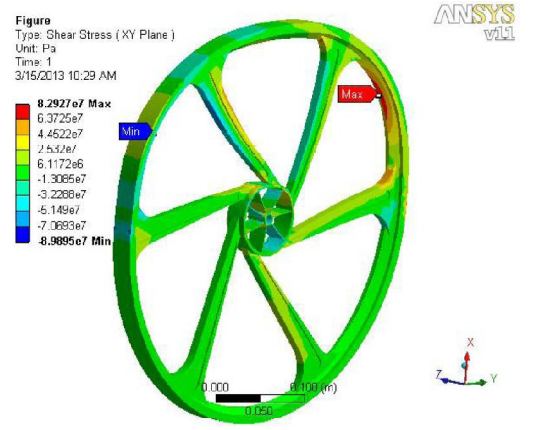


Figure 5: Stress Ratio of Aluminum

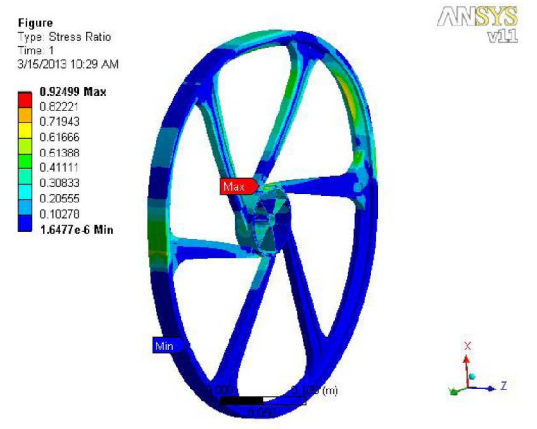
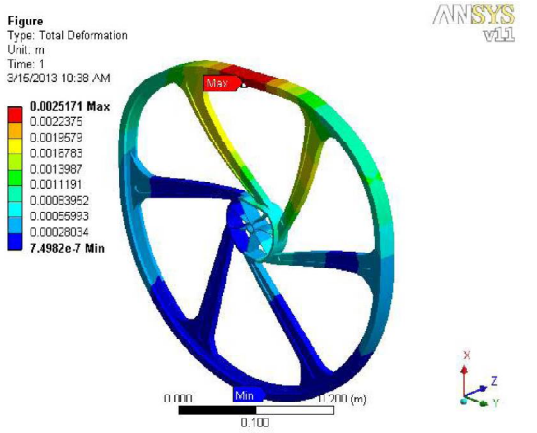


Figure 6: Total Deformation of Magnesium



APPENDIX (CONT.)

Figure 7: Equivalent Stress of Magnesium

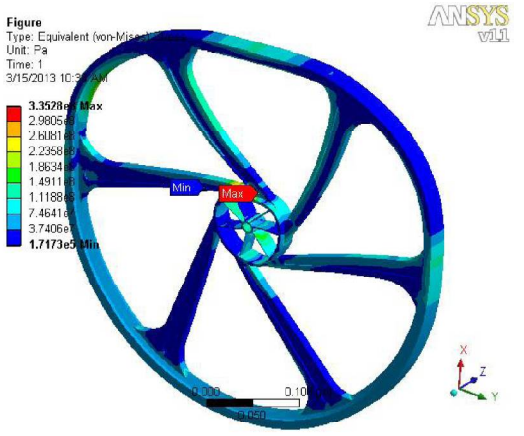


Figure 8: Normal Stress of Magnesium

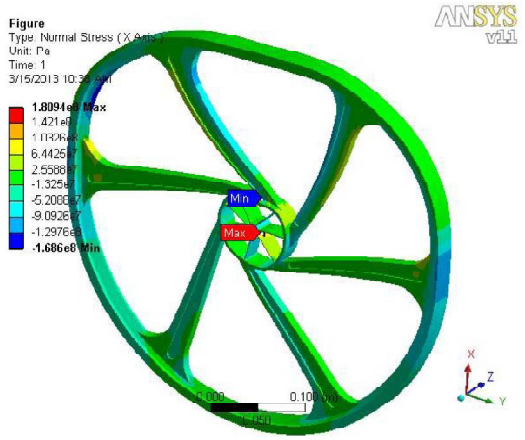


Figure 9: Shear Stress of Magnesium

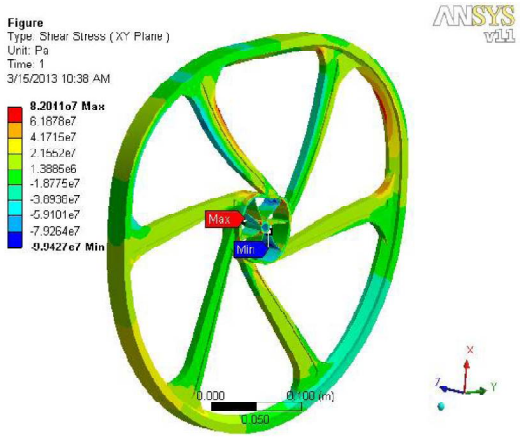


Figure 10: Stress Ratio of Magnesium

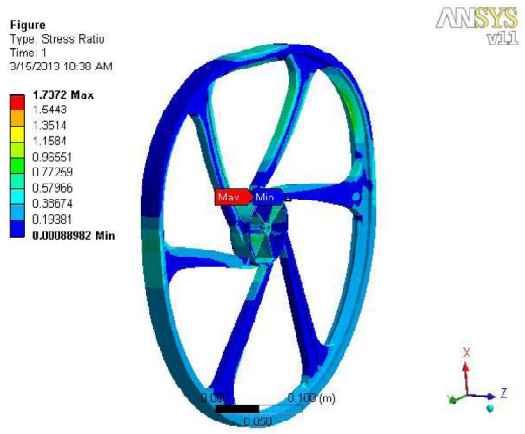


Figure 11: Total Deformation of Carbon Fiber

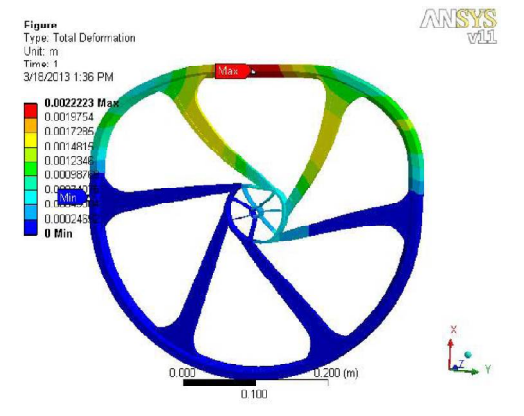
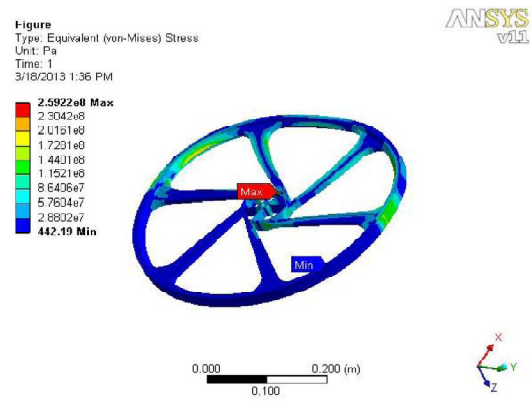


Figure 12: Equivalent Stress of Carbon Fiber



APPENDIX (CONT.)

Figure 13: Normal Stress of Carbon Fiber

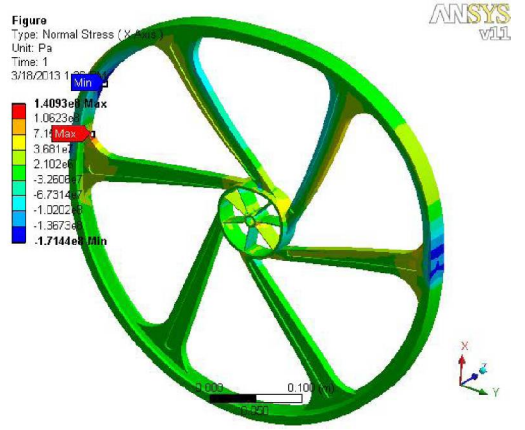


Figure 14: Shear Stress of Carbon Fiber

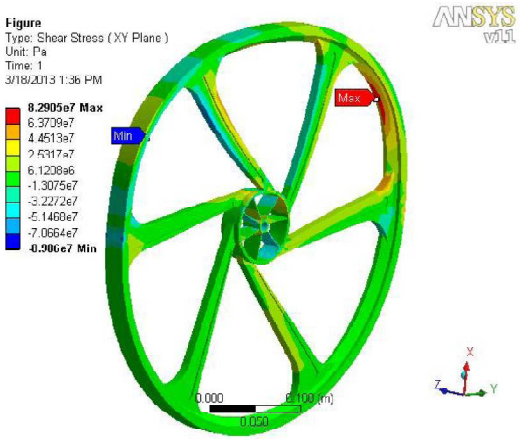


Figure 15: Stress Ratio of Carbon Fiber

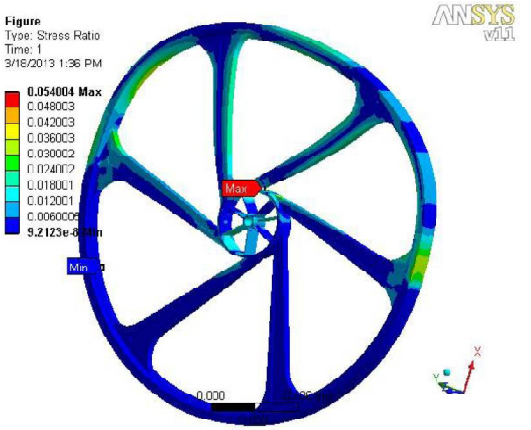


Figure 16: Total Deformation of Thermoplastic Resin

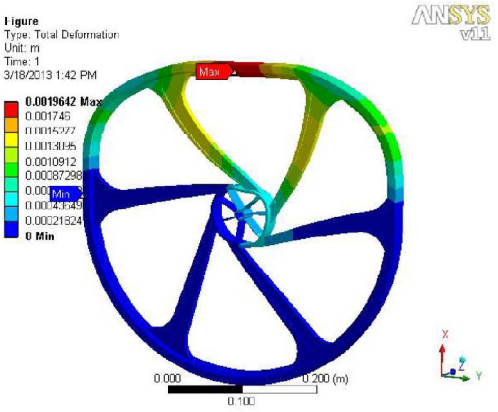


Figure 17: Equivalent Stress of Thermoplastic Resin

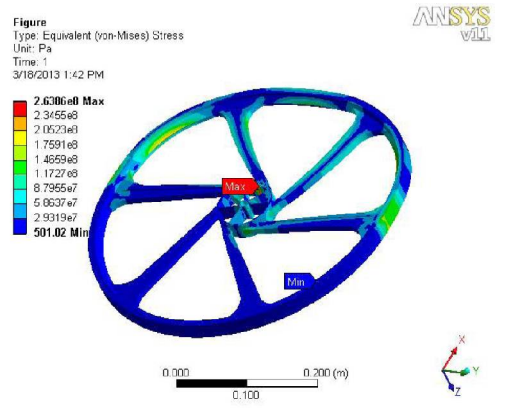
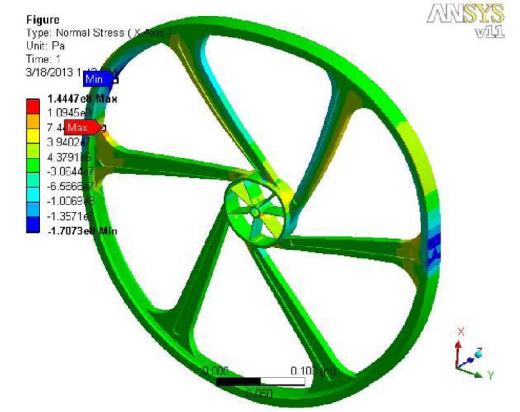


Figure 18: Normal Stress of Thermoplastic Resin



APPENDIX (CONT.)

Figure 19: Shear Stress of Thermoplastic Resin

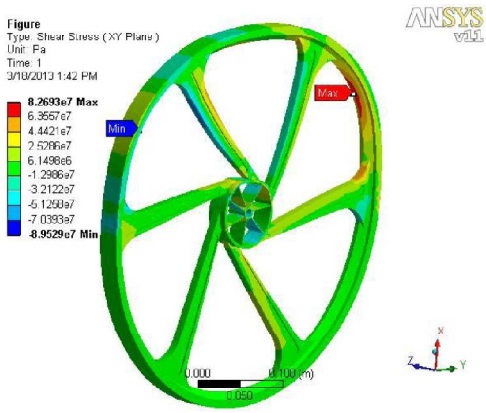


Figure 20: Stress Ratio of Thermoplastic Resin