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Research Paper

MODELLING AND ANALYSIS OF ALLOY WHEEL FOR FOUR WHEELER VEHICLE

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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 normal steel wheels because of their lighter weight, which improves the steering and the speed of the car. Alloy wheels will reduce the unstrung weight of a vehicle compared to one fitted with standard steel wheels. The benefit of reduced unstrung weight is more precise steering as well as a nominal reduction in fuel consumption. Alloy is an excellent conductor of heat, improving heat dissipation from the brakes, reducing the risk of brake failure under demanding driving conditions. At present four wheeler wheels are made of Aluminum Alloys. In this project, Aluminum alloy are comparing with other Alloy. In this project a parametric model is designed for Alloy wheel used in four 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 like shaft of the axle and bolts PCD of the car. Car model is Ford Fiesta.

Keywords: Alloy wheel, Static analysis, Fatigue analysis, Model analysis, Aluminum alloy, Magnesium alloy, Zinc alloy

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 labour 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 only a few types of wheels still in use in the automotive industry today. They vary significantly in size, shape, and materials used, but all follow the same basic principles.

The first type of wheel worth mentioning, and by far the most-used wheel, is the steel wheel. This kind of wheel consists of several sheets of steel, stamped into shape and typically welded together. This type of wheel is strong, but heavy. They are found on every kind of vehicle from sports cars to the larger pickup trucks; the wheels look different but are essentially the same device.

The second type of wheel to be mentioned is the rally wheel. These are essentially steel wheels but they are made somewhat differently, and tend to consist of a heavier gauge of steel. While the inner portion of a steel wheel is generally welded to the rim along its entire circumference, a steel wheel's inner portion is cut to resemble the spokes of a mag wheel, and is welded accordingly.

Mag wheels are cast and/or milled wheels typically made from aluminum or an alloy thereof. They used to be made of magnesium for their light weight and strength, but magnesium catches fire somewhat easily and is very difficult to put out. This is unfortunate, because it is superior to aluminum in every other way. This tendency also makes it a dangerous metal to work with, because piles of shavings tend to burst into flame and burn through concrete surfaces when they get too hot.

As previously mentioned, spoke wheels (sometimes with more than 100 spokes) are still in use today and are popular on roadsters and low-riders. They tend to be fairly low in weight, and are reasonably strong. They have an "old school" appearance and style which is often highly sought after.

Various combinations of these technologies can be used to produce other, more unusual wheels. Large earth-moving vehicles such as the more gargantuan dump trucks often have some degree of the vehicle's suspension actually built into the wheel itself, lying between the hub and rim in place of spokes. Also, various companies make wheels which are designed like steel wheels but are made of aluminum. The most famous of these are made by centerline, and the style is actually called the centerline wheel.

SPECIFICATION OF THE PROBLEM

Aluminum alloy are comparing with other Alloy. In this project a parametric model is designed for Alloy wheel used in four 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 like shaft of the axle and bolts PCD of the car. Car model is Ford Fiesta.

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 reinforced composites is their high interal damping capacity. This leads to better vibration energy absorption within the material and 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 tradional metalic 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 mettalic 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 Ford Fiesta car. The typical chemical composition of the material for Alluminium alloy(%) is copper-0.25,maganese-0.35,silicon-6.5 to 7.5, iron-0.6%, zinc-0.35, others-0.05, alluminum-87 to 100.

Magnisium 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.

Table 1: Specifications of Alloy Wheel

S. No.	Parameters	Value
1.	Area	196761.05 mm^2
2.	Diameter	280 mm
3.	Perimeter	1759.29 mm
4.	Weight of the Car	1.5 Tonnes
5.	Passenger 5 People	400 KG
6.	Extra Load	500 KG
7.	Total	23520 N
8.	Tyres and Suspension Reduced by 30%	16464 N
9.	Weight on Individual Wheel	4116 N
10.	Pressure	0.08 N/mm^2

Zincalloy (%) isalluminum-3.7 to 4.3, copper-0.1, iron-0.05, lead-0.003, cadmium-0.002, tin-0.001, nickel-0.005 to 0.020, zinc-70 to 100.

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).

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):

- Externally applied forces and pressures.
- Steady-state inertial forces (such as gravity or rotational velocity).
- Imposed (non-zero) displacements.
- Temperatures (for thermal strain).

Table 2: Comparative Static Analysis of Alloy Wheels for Different Materials

	Static Analysis					
	Stress (N/mm^2)		Displacement (mm)		Strain	
	Min	Max	Min	Max	Min	Max
Alluminuim	0.00165150	2.11428	0	0.00382573	1.61658e-008	2.53612e-005
Zinc	0.00167229	2.11602	0	0.00325493	1.29709e-008	2.11336e-005
Magnesium	0.00139368	2.10330	0	0.00617055	2.96084e-008	4.26829e-005

CONCLUSION

A fatigue lifetime prediction method of alloy wheels was proposed to ensure their durability at the initial design stage. To simulate the rotary fatigue test, static load FEM model was built using COSMOS. The analysis results showed that the maximum stress area was located in the hub bolt whole area agreed with the fact. 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 amplitude. The simulation result showed that baseline design fatigue life was lower than 1 × 105. After improving the weakness area of alloy wheels, the improved wheel life cycle exceeded 1 × 105 and satisfied the design requirement.

Alloy wheel rotary fatigue bench test was conducted. The test result showed that the prediction of fatigue life was consistent with the physical test result. 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, strain, displacement, total

Table 3: Comparative Fatigue Analysis of Alloy Wheels for Different Materials

	Fatigue Analysis					
	Total Life (Cycles)		Damage Factor		Load Factor	
	Min	Max	Min	Max	Min	Max
Alluminuim	1e + 006	1e + 006	10	10	92.7230	115533
Zinc	1e + 006	1e + 006	10	10	108.7550	130539
Magnesium	1e + 006	1e + 006	10	10	57.8465	80884.7

life, load factor and damage factor we suggest that aluminum alloy is the best material for the alloy wheel (Table 3).

Table 4: Comparative Frequency Analysis of Alloy Wheels for Different Materials

Frequency Analysis		
	Displacement (mm)	
	Min	Max
Alluminuim	0	962.280
Zinc	0	612.849
Magnesium	0	1208.220

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APPENDIX

Figure 1: Stress on Alluminium Alloy

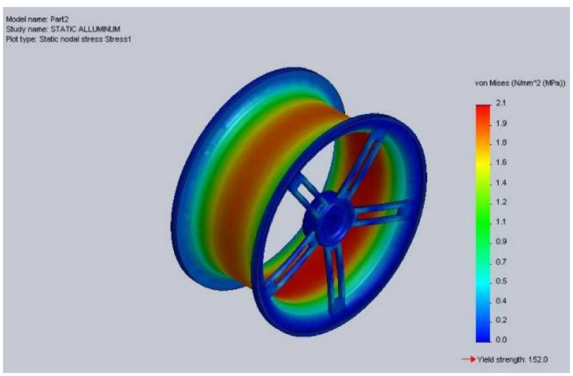
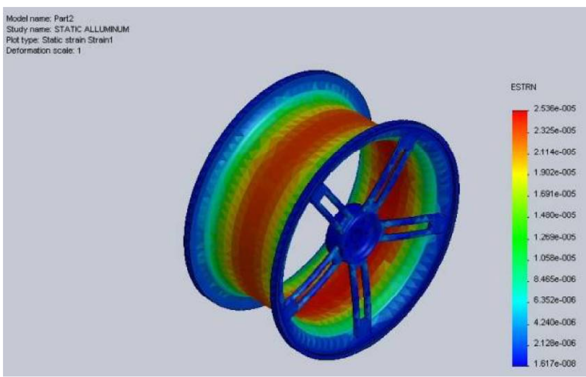


Figure 2: Strain on Alluminium Alloy



APPENDIX

Figure 3: Displacement on Alluminium Alloy

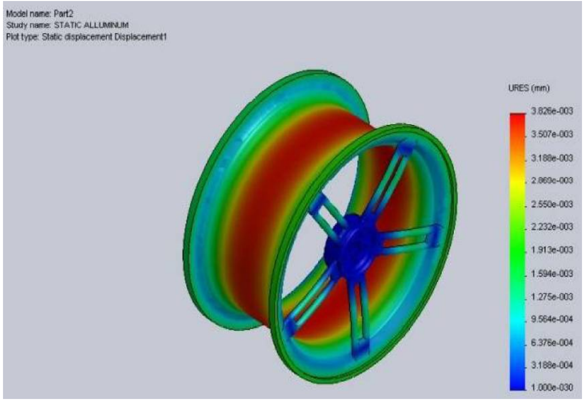


Figure 4: Stress on Magnesium Alloy

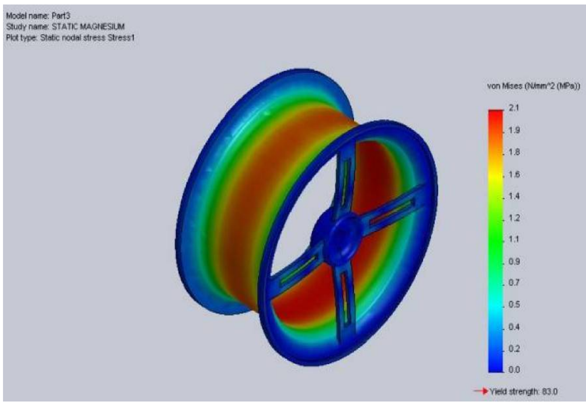


Figure 5: Displacement on Magnesium Alloy

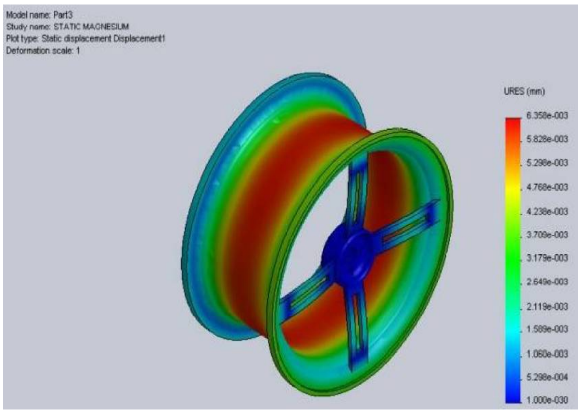


Figure 6: Strain on Magnesium Alloy

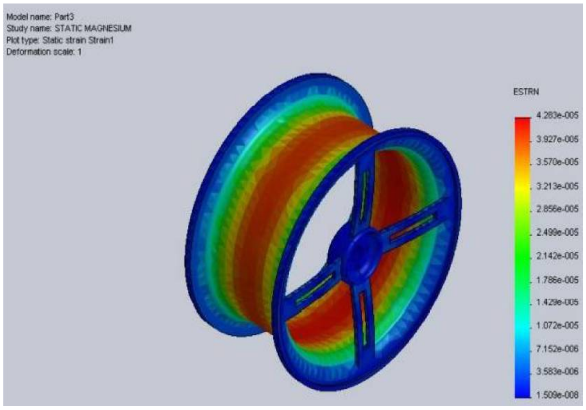


Figure 7: Stress on Magnesium Alloy

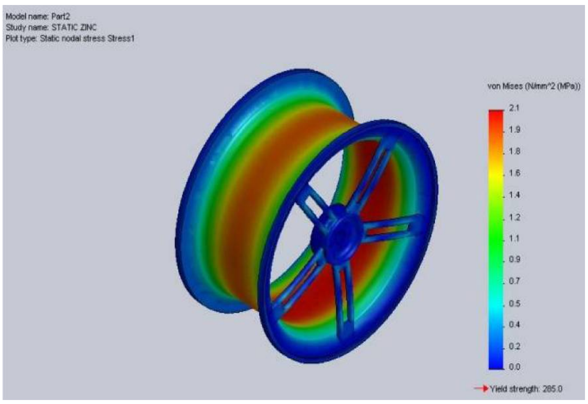
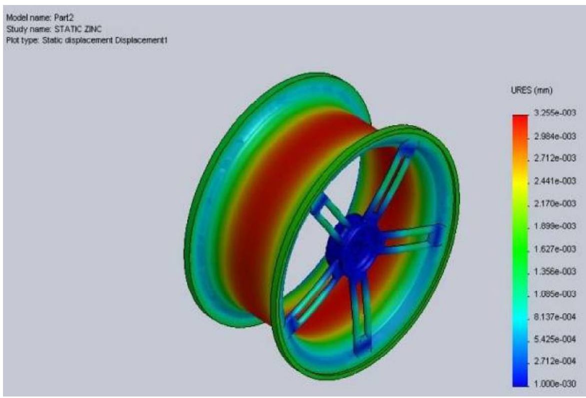


Figure 8: Displacement on Magnesium Alloy



APPENDIX (CONT.)

Figure 9: Strain on Magnesium Alloy

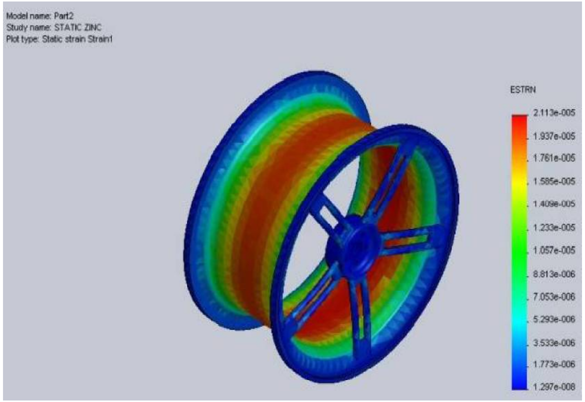


Figure 10: Total Life on Alluminium Alloy

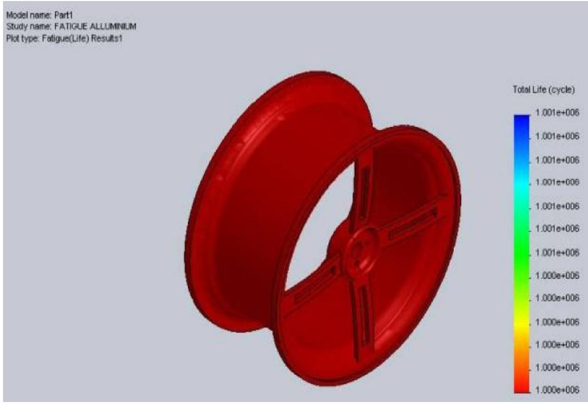


Figure 11: Damage Percentage on Alluminium Alloy

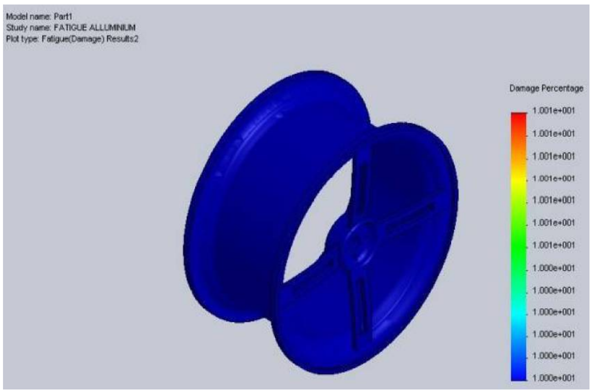


Figure 12: Load Factor on Alluminium Alloy

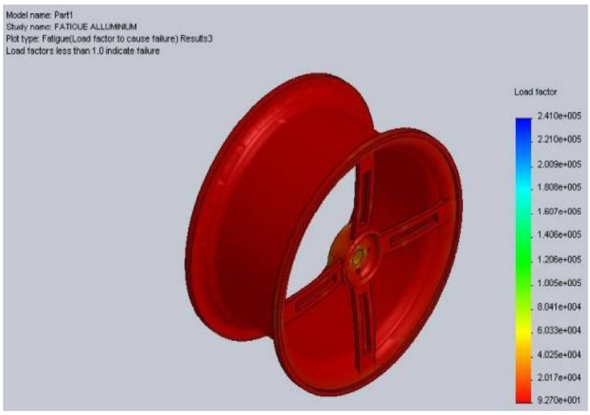


Figure 13: Total Life on Magnesium Alloy

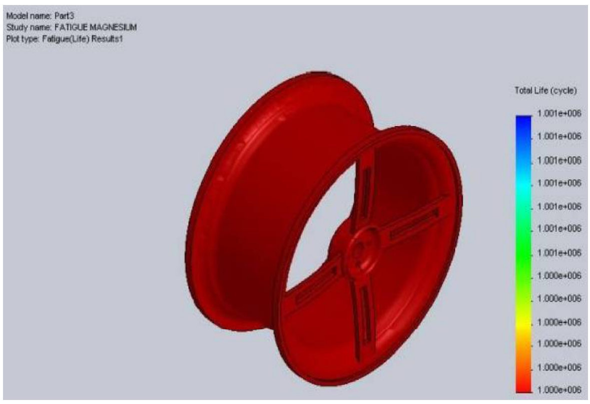
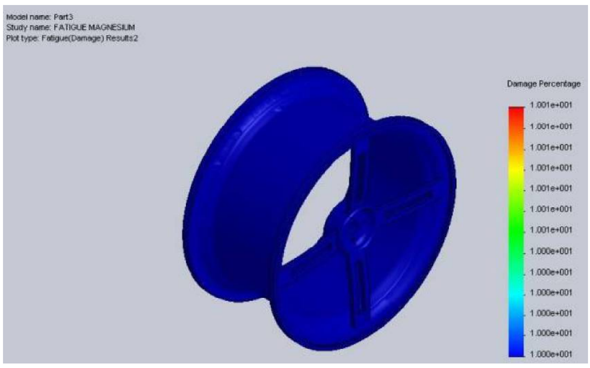


Figure 14: Damage Percentage on Magnesium Alloy



APPENDIX (CONT.)

Figure 15: Load Factor on Magnesium Alloy

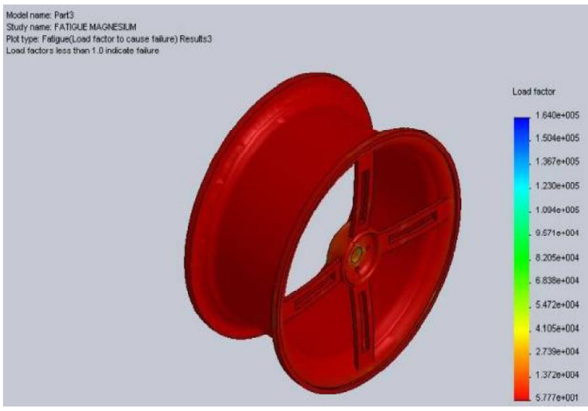


Figure 16: Total Life on Zinc Alloy

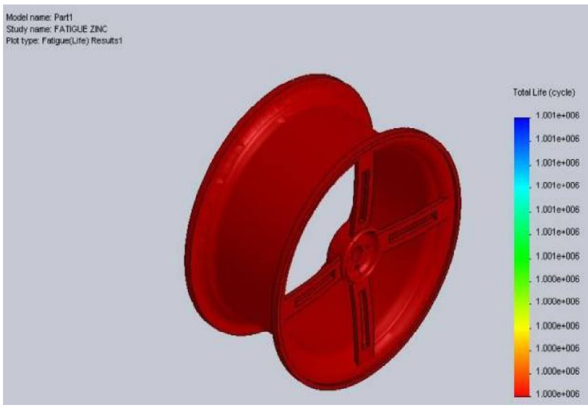


Figure 17: Damagage Percentag on Zinc Alloy

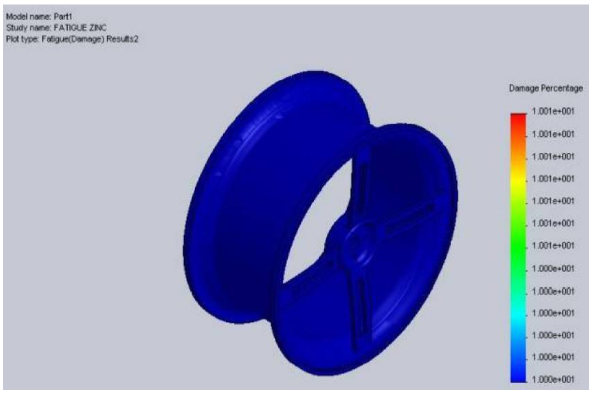


Figure 18: Frequency of Alluminium Alloy

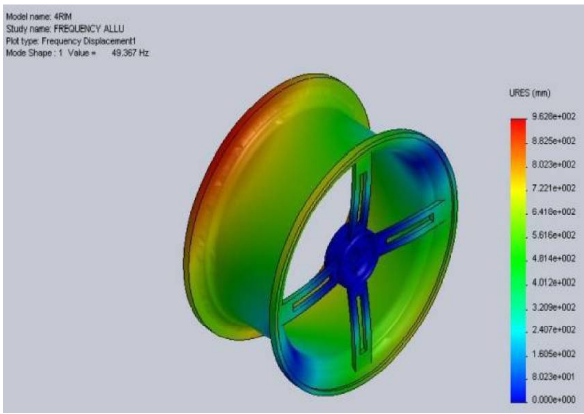


Figure 19: Frequency of Magnesium Alloy

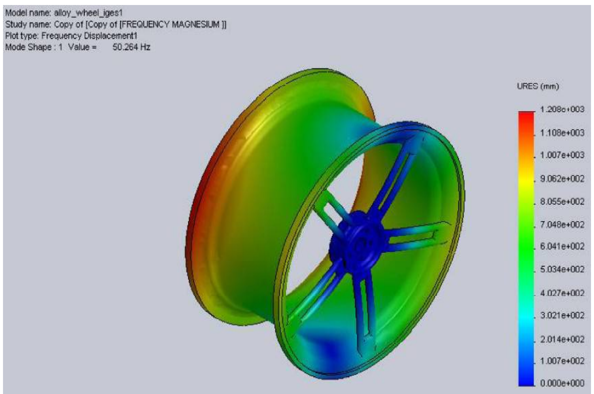
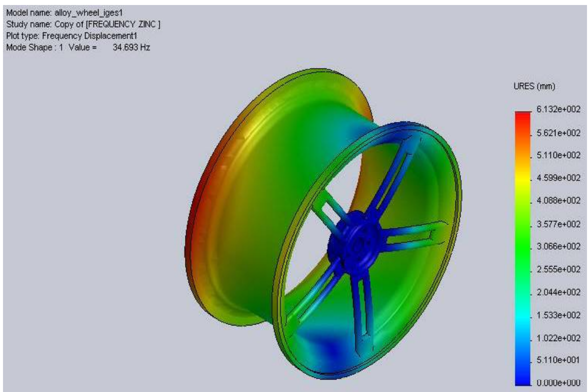


Figure 20: Frequency of Zinc Alloy



APPENDIX (CONT.)

Figure 21: SN Curves for Alternating Atress and Cycles of a Aluminum Alloy

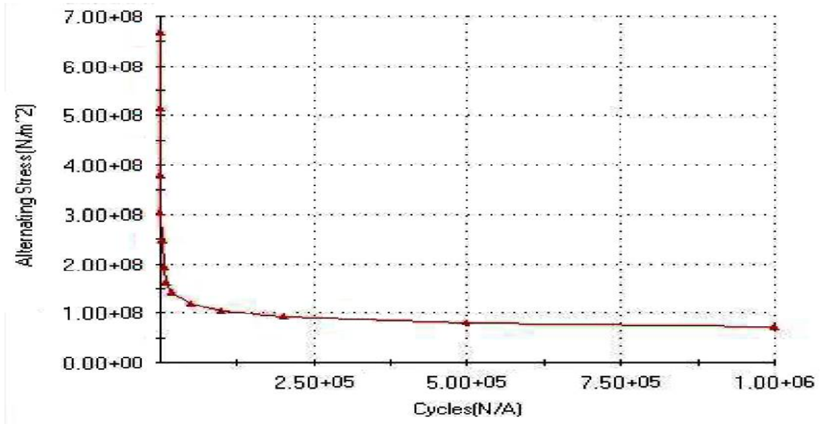


Figure 22: SN Curves for Alternating Stress and Cycles of a Magnesium Alloy

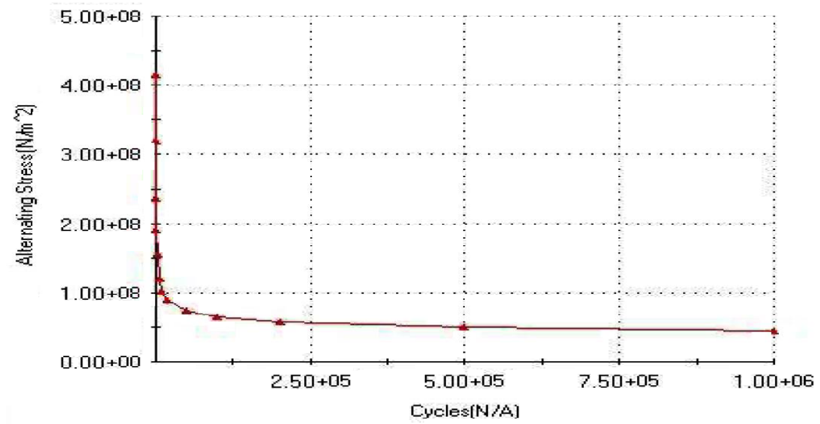


Figure 23: SN Curves for Alternating Stress and Cycles of a Zinc Alloy