Abstract
In the present project a detailed static and fatigue analysis of aluminum alloy wheel under a radial loads has been done. Analysis of aluminum alloy wheel A356.2 was carried out using FEA package. The 3 dimensional model of the wheel was designed using CATIA. Then the IGES format 3-D model was imported into ANSYS.

The present thesis summarizes the application of finite element analysis technique for analyzing stress distribution and fatigue life of Aluminum alloy wheels subject to radial loads. Alloy wheels intended for use on passenger cars stipulate two types of fatigue tests, the dynamic cornering fatigue test and the dynamic radial fatigue test. As wheels undergo inconsistent, varying loads during their service life, fatigue behavior is a key consideration in the design and performance evaluation. But since alloy wheels are designed for styling and have more complex shapes than regular steel wheels, it is difficult to assess fatigue life by analytical methods. So, finite element analysis has been used to evaluate the performance of wheels over their life.

Keywords
Fatigue, Aluminum Alloy, Finite Element Analysis (FEA)

Literature
In 19th century, it was considered to be mysterious that fatigue fracture did not show a visible plastic deformation. Systematic fatigue fractures tests were done in laboratories, notable by August Wohler. It was recognized that small radii in the geometry should be avoided. Fatigue was considered to be an engineering problem.

Ewing and Humfrey made the fundamental step regarding fatigue as a material problem in the beginning of 20th century in 1903. They carried out a microscopic investigation, which showed that fatigue crack nuclei start as micro crack in slip bands. Much more evidence about fatigue as a material phenomenon was going to fall in the 20th century.

Fatigue as a technical problem became more evident around the middle of 19th century. About 100 years later, in the middle of 20th century, Peterson in 1950 and Timoshenko in 1954 reviewed the developments of fatigue problems in two historical papers. Peterson reviewed the discussion on fatigue problems during meetings of mechanical engineers at Birmingham held in 1850. He also mentioned historical ideas about fatigue as a material phenomenon and the microscopic studies carried out by Gough and co-workers and others in 1930.

Wholer carried out experiments to obtain S-N curves in the 19th centuries. For a long time such curves were labeled as a Wholer curve instead of the no more frequently used term S-N curve. In 20th century numerous fatigue tests were carried out to produce large number of S-N curves. In the beginning, rotating bending beam tests on unnotched specimens were popular because of more simple experimental facilities available. Especially engineers recognized the significance of testing unnotched specimens. The testes were performed with a constant mean stress and constant mean amplitude. For low stress amplitude, the S-N curve exhibited a lower limit, which implies that fatigue failures did not occur after high number of load cycles.

Introduction to Aluminum Alloy Wheels
A. Introduction to Alloy Wheels
Alloy wheels were first developed in the last sixties to meet the demand of racetrack enthusiasts who were constantly looking for an edge in performance and styling. It was an unorganized industry then. Original equipment manufacturers soon realized that a significant market opportunity was being lost as car owners were leaving car show rooms with stock wheels and driving down to a dealer for fitment with high priced custom alloy wheels. Since its adoption by OEM’s, the alloy wheel market has been steadily growing.

B. History of Alloy Wheel in India
In India first aluminum wheel industry was started in a Hyderabad company which made aluminum under the brand name “ZOOM”. Then a young vocational metallurgical from Coimbatore started manufacturing these on a commercial basis and marketing them nationally under the “RADO” as the brand name of the company Sri Durga metal alloy.

C. Introduction to Aluminum Alloy A356.2
Aluminum is a weak material in its pure form, prone to oxidation and is not readily cast able. Strength and other mechanical properties are improved mixing it with other elements. The alloy name is A356.2, where the decimal 0.2 stands for grain modifier percentage called Strontium.

Analuminum alloy wheel, commonly referred to as “MAG WHEEL”, “ALLOY WHEEL” or “STYLISED WHEEL” is made from an alloy of aluminum, silicon and magnesium. This alloy inhibits superior strength-to-weight ratio over steel wheels and as such represents the ideal material from which to create a high performance wheel. In fact, totally it is hard to imagine a world class racing car or high performance road vehicle that does not use alloy wheels.

Aluminum Alloy 356.2:
Category - Aluminum Alloy
Class - cast

Composition:
- Aluminum - 92.4 %,
- Silicon - 6.5 to 8 %,
- Magnesium - 0.25 to 0.4 %,
- Titanium - 0.2 %,
- Iron - 0.12 %,
- Manganese - 0.14 %,
- Strontium - 0.2 %

Mechanical Properties:
- Young’s modulus (mpa) - 6.9*E4
- Density (*1000kg/m) - 2.68*10-9
Poisons ratio - 0.33
Elastic modulus (g.pa) - 70 – 80
Tensile strength (m.pa) - 175
Yield strength (m.pa) - 140
Elongation % - 2.0

D. Aluminum Wheels
But aluminum wheels are cast into a mold in a hot liquid state and cooled, which makes them more accurate in both the heavier and lighter areas. The end result is a balance that has less weight on the wheel and less stress on the tire.

Steel wheels are a great way to provide basic transportation for a basic car, but for those who want to extend the life of their tires and have a smoother ride; alloy wheels are the way to go. Aluminum wheels also provide a lighter weight for the racing enthusiast, and can be machined for a brilliant appearance.

E. Aluminum Alloy Properties
The aluminum alloy in general can be characterized as enteric systems, containing inter metallic compounds or elements as the excess phases because of relatively low solubility’s of most of the alloying elements in aluminum and the complexity of the alloys that are produced any one base alloy may contain several metallic phases, which sometimes are quiet complex in composition. These phases usually are appreciably more soluble near the eutectic temperature than at room temperatures, making it possible for heat treatment some of the alloys by solution and age treatments.

Pure aluminum being poor casting materials, aluminum castings are actually produced from alloys. The casting alloys used is those having the properties particularly suited to casting purposes. For all the alloys, two types of properties, those characteristics of the alloy which determine the ease or difficulty of producing acceptable castings and the engineering properties, those properties, those properties which are of interest to the designer or user of the castings, these two set of properties can be used as basis for studying the wheel performance.

F. Benefits of Aluminum Alloy Wheels
Aluminum alloy wheels are made with state of art low pressure die-casting technology for which they following benefits:

1. Reduced weight
   This is one of the most critical factors affecting a vehicle’s road holding capacity. Weight is that portion of vehicle that is not supported by the suspension, i.e. Wheels tyres and breaks, and there therefore the most susceptible to road shocks and cornering forces. By reducing weight, alloy wheels provide better ride and braking, precise steering and improved ‘turning in’ characteristic.

2. Improved Acceleration
   By reducing the weight of the vehicle’s rational mass, alloy wheels provided more responsive acceleration and braking, and increases fuel efficiency.

3. Add Rigidity
   The added strength of a quality alloy wheel can significantly reduce wheel of tyre reflection in cornering. This is a particularly tyre where lateral forces may approach 1.0g.

4. Increased Brake Coding
   The metals in alloy wheels are excellent. Conductors of heat-improving heat dissipation from the brakes. This helps reduce the risk of fade under demanding conditions whereby improve braking efficiency, brake life and tyre life.

G. Manufacturing Process of Alloy Wheel

Fig. 1: A Block Diagram of Alloy Wheel A Die Tool Assembly

Fig. 2: A Die Tool Assembly Die Tool For Typical LPDC Process

III. Fatigue Analysis

A. Introduction
   It has been observed that material fail under fluctuating stresses. It is a stress magnitude which is lower than the ultimate tensile strength of the material the decreased resistance of the materials to fluctuating stresses is called FATIGUE.

There is a basic difference between failure due to static load and that due to fatigue. The failure due to static load is illustrated by the simple tension test. And there is sufficient time for elongation...
of fibers. In this case the load is gradually applied. The fatigue failure begins with a crack at some point in the material. The crack is more likely to occur in the following regions:

- Regions of discontinuity, such as oil holes, key ways, screw threads etc.
- Regions regulations in machining operations, such as scratches on the surface, stamp mark, inspection marks etc.
- Internal crack due to defects in materials like holes.

1. Types of Fatigue:
- Low cycle fatigue
- High cycle fatigue

(i). Low Cycle Fatigue
The underlying principle of the Low Cycle Fatigue (LCF) philosophy for the description of the Fatigue reliability of mechanical components and structures is based upon the premise that an Understanding of cycle-by-cycle variations in the stress-strain behavior of a material at the most Highly strained region in a member should be sufficient to predict the fatigue life characteristics at this location.

(ii). High Cycle Fatigue
High-Cycle Fatigue has been identified as a leading cause of turbine engine failures, excessive maintenance costs, and source of responsibility for numerous stand downs affecting operational readiness over the past decade. High-Cycle Fatigue (HCF) is fatigue that occurs at relatively large numbers of cycles and is caused by high frequency vibrations in both static and rotating hardware.

2. Types of Fatigue Tests:

(i). Fatigue Test
A metal subjected to repetitive loads below the yield stress may fail after a certain number of cycles. Failure of materials under cyclic loading is called fatigue failure, and techniques for measuring susceptibility to fatigue failure are called fatigue testing. Fatigue may account for at least 90% of all service failures due to mechanical causes.

Most fatigue failure start at the surface and progress slowly initially. After the slowly growing crack has reduced the cross sectional area sufficiently, fracture occurs suddenly. The first portion of the fracture-propagation process yields a fracture surface that usually is significantly different from the second portion. The slowly growing portion produces striations at each cycle, corresponding to each small advance of the crack front. Sometimes subsequent rubbing of the surfaces eliminates these striations. The second portion of the fracture, corresponding to the rapid propagation of the crack, shows surface features typical of tensile fracture. Fatigue of wheels is the property by which they fail at a relatively low value of stress when the stress is repeated; in fatigue following two tests are conducted.

(ii). Dynamic Cornering Fatigue Test
The test machine shall have a driven rotate able device whereby either the wheels rotates under the influence of a stationary bending moment or the wheel is stationary and is subjected to a rotating bending moment.

A finished wheel is selected from a lot work order size. The rim flange of a wheel is clamped to the test fixture and fastened using a torque of minimum 12kgf.m. The run out of the test wheel is checked by a dial guage. Set the cycle time, load to be applied and the RPM as required. Ensure that the safety net is closed before starting the test. By setting the tester on and applying the required load the test is started. The bending moment shall maintained ±2.5% in the final clamp position. The wheel shall be concentric to the rotating device with 0.25mm more at the point of loading in the unloading condition. The details of the load applied, cycle time and RPM are recorded in the check list. The test results are verified after completion of the test. The wheel is accepted if no cracks are observed during die penetrate test.

(iii). Dynamic Radial Fatigue Test:
The test machine is equipped with a means of imparting a constant radial load only as the wheel rotates. The equipment incorporates a driven ratable drum set which prevents a smooth surface wider than the loaded test tyre section width. The preferred diameter of the drum is 1700mm.A finished wheel is selected from a lot/work order size. A suitable tyre is fitted and tyre pressure should be minimum of 65psi. The fitment of the test wheel is arranged on to the fixture and fastened using a torque of minimum 12kgf.m.

Set the cycle time, RPM and load to be applied

B. Discussion About Fatigue
Most machinery and many structures do not operate under a constant load and stress. In fact, these loads and stresses are constantly changing. A good example of this is a rotating shaft such as the axle on a railroad car. The bending stresses change from tension to compression as the axle rotates. This constant change in stress can cause fatigue failure in which the material suddenly fractures. The process that leads to fatigue failure is the initiation and growth of cracks in the material. Fracture occurs when the crack grows so large that the remaining uncracked material can no longer support the applied loads.

Different stress definitions are used in typical fatigue analyses. Four are evident from Fig. 3(a) and are the maximum stress, S_max, the minimum stress, S_min, the mean stress, S_mean and the amplitude stress, S_amp. The later two are given by the following equations:

\[ S_{\text{mean}} = \frac{S_{\text{max}} + S_{\text{min}}}{2} \]

And

\[ S_{\text{amp}} = \frac{S_{\text{max}} - S_{\text{min}}}{2} \]

Note that the mean stress may be negative (compressive stress) or positive (tensile stress) while the amplitude stress must be positive. For Fig. 3(b), both S_min and S_amp are positive. Furthermore, both S_max and S_min are positive, indicative of a cyclic loading where he stresses are always tensile. A purely compressive stress cycle could similarly be prescribed.

Schematic of different loading conditions in (a), the cyclic loading is everywhere tensile, in (b) the random loading shows both tensile and compressive components with no well defined maximum or minimum stresses, and in (c) the cyclic loading alternates between tensile and compressive stresses of equal magnitude.

This is the type of stress cycle that will be used in this lab to characterize the fatigue behavior of an Al-alloy. Though simple
relative to the random stress history of Fig. 3(c), it supplies information on the basic fatigue resistance of a material so that a more complex (statistical or plastic) analysis may be undertaken.

Fig. 3(a)

$$S_{\text{max}} - S_{\text{min}}$$

Fig. 3(b)

$$S_{\text{max}} = S_{\text{mean}}$$

Fig. 3(c)

1. Tensile and Compressive Charts

(i). S-N Diagram

Well before a micro structural understanding of fatigue processes was developed, engineers had developed empirical means of quantifying the fatigue process and designing against it. Perhaps the most important concept is the S-N diagram, the figure shows in which a constant cyclic stress amplitude $S$ is applied to a specimen and the number of loading cycles $N$ until the specimen fails is determined. Millions of cycles might be required to cause failure at lower loading levels, so the abcissa is usually plotted logarithmically.

2. S − N Curves for Aluminum and Low-Carbon Steel

In some materials, notably ferrous alloys, the S − N curve flattens out eventually, so that below a certain endurance limit $\sigma_e$ failure does not occur no matter how long the loads arecycled. Obviously, the designer will size the structure to keep the stresses below $\sigma_e$ by a suitablesafety factor if cyclic loads are to be withstood. For some other materials such as aluminum, noendurance limit exists and the designer must arrange for the planned lifetime of the structure to be less than the failure point on the S − N curve.

- The fatigue strength ($S_f$) initially starts at a value of $S_n$ at $N=0$ and declines logarithmically with increasing cycles
- In some materials at $10^6 - 10^9$ cycles, the S-N diagram and the fatigue strength remains constant the fatigue strength or endurance limit are typically determined from the standard material tests (e.g. rotating beam test) however, they must be appropriately modified to account for the physical and environmental differences between the test specimen and the actual part being analyzed:

$$S_1' = \text{corrected strength}$$

$$S_1'' = \text{Strength determined from standardized test}$$

- for materials that possess an endurance limit the coefficients $(a,b)$ can be calculated from the following two points

$$S_n = S_m \text{ at } N=10^3$$

$$S_n = S_e \text{ at } N=10^6$$

- for materials that do not possess an endurance limit, use

$$S_n = S_m \text{ at } N=10^3$$

$$S_n = S_f \text{ at } N=5 \times 10^8$$

C. Fatigue Strength and Endurance Limit

It has been found experimentally that when a material is subjected to repeated stresses, it fails as stresses below the yield point stresses. Such type of failure of a material is known as fatigue. The failure is called by means of a progressive crack formation which is usually fine and of microscopic size. The failure may occur even without any prior indication. The fatigue of material is effected by the size of the component, relative magnitude of static and fluctuating loads and the number of load reversals. The endurance limit is used for reversed bending only while for other types of loading, the term endurance strength may be used when referring the fatigue strength of the material, it may be defined as the safe maximum stress which can be applied to the machine part working under actual conditions

D. Characterizing Flictuating Stresses

Fluctuating stresses often sinusoidal, but as along as the wave has a periodic pattern exhibiting a single maximum and minimum, its shape is not important.
E. Fatigue Failure Criteria

- Similar to the static failure analysis, a failure envelope is constructed using the mean and amplitude stress components.
- Under pure alternating stress (i.e. $\sigma_a$ only) the part should fail at $S_e$ or $S_f$ whereas, under pure static stress (i.e. $\sigma_m$ only) the part should fail at $S_{ut}$.
- Thus, the failure envelope is constructed on a $\sigma_a - \sigma_m$ plot by connecting $S_e$ (or $S_f$) on the $\sigma_a$-axis with $S_{ut}$ on the $\sigma_m$-axis.

IV. Modelling of Alloy Wheel

Introduction to Catia

![Fig. 7: Catia Features](image)
A. Features of Catia
- Easy accessible software
- Predefined shapes
- Powerful in surfacing
- User pattern facilities
- Supports CSG and feature based
- Retrieving data is very easy

1. Design Process
- Sketching using basic sketch entities.
- Converting the sketch into feature and parts.
- Assembly different parts and analysis them
- Manufacturing of the final parts and assembly

B. Catia Functionality
- The basic functionality of catia is broken into several areas

1. Part Design
- Create sketched features including, cuts, and slots made by either, extruding, revolving sweeping along 2-d sketched trajectory, or blending between parallel sections, create “pick and place” features, such as holes, shafts, chamfer, rounds, shell, regular drafts, flanges ribs etc.
- Sketch cosmetic features, reference datum planes, axes, points, curves, coordinate systems, and shapes for creating non solid reference datum, modify, delete, suppress, redefine, and reorder features. Suppress, redefine, and reorder features. As well as making features “read only”.
- Create geometric tolerances and surface finished on models, assign defines, units, material properties or user specified mass properties to a model

2. Assembly Design
- Place components and sub assembly using components like made align, and insert to create full produce assemblies.
- These assembly components from an assembly.
- Modify assembly placement offsets.
- Create and modify assembly datum planes coordinate systems.
- Modify part dimensions in assembly mode.
- Generate engineering information, fill of material, reference dimensions and assembly mass properties

C. Design Documentation
- Use sketch parametric drawing format.
- Manipulate dimensions.
- Update the modal geometry to incorporate design changes.
- Export a drawing into IGES file.

V. Fatigue Analysis Using Fea Package

A. Introduction
The finite element is a mathematical method for solving ordinary and partial differential equations. Because it is a numerical method, it has the ability to solve complex problems that can be represented in differential equation form. As these types of equations occur naturally In virtually all fields of the physical sciences, the applications of the Finite element method are limitless as regards the solution of practical

1. Design Problem
Due to the high cost of computing power of years gone by, FEA has a history of being used to solve complex and cost critical problems. Classical methods alone usually cannot provide adequate information to determine the safe working limits of a major civil engineering construction or an Automobile or a Nuclear reactor failed catastrophically the economic and social costs would be unacceptably high.

The finite element method is a very important tool for those involved in engineering design; it is now used routinely to solve problems in the following areas:
- Structural Strength design
- Structural interaction with fluid flows
- Analysis of shock (underwater & in materials)
- Acoustics
- Thermal analysis
- Vibrations
- Crash simulations
- Fluid flows
- Electrical analyses
- Mass diffusion
- Buckling problems
- Dynamic analyses
- Electromagnetic evaluations
- Metal forming
- Coupled analyses

B. Advantages of Finite Element Analysis
In contrast to other variation and residual approaches the finite element method does not require trial solutions, which apply to entire multi dimensional continuum.
- The use of separate sub regions, or finite elements, for the trial solutions permits a greater flexibility in considering of complex shape.
- Rather than requiring every trail solution to satisfy the boundary conditions, one prescribes the conditions after obtaining the algebraic equations for the assemblage.
- As boundary conditions do not enter in to equations for the individual finite elements, one can use the same field variable for both internal and boundary elements.
- The filed variable models need not be changed when the boundary conditions change.
- The introduction of boundary conditions in to assembled equations is a relatively easy process. No special techniques or artificial device are necessary.

C. Limitations of Finite Element Analysis:
The finite element method does not accommodate few complex phenomena such As
- Cracking and fracture behavior.
- Contact problems.
bond failures of composite materials.
  - Non-linear behavior with work softening.
  - It does not account for transient, unconfined seepage problems.
  - The finite element analysis has reached a high level of development as a solution technique. However, the method yields realistic results only if the coefficients or material parameters, which describe the basic phenomena, are available.
  - The most tedious aspect of the use of finite element method is the basic process of sub dividing the continuum error free input data for the computer.

D. Analysis Types Available
  - Structural static analysis.
  - Structural dynamic analysis.
  - Structural buckling analysis.
  - Linear buckling.
  - Nonlinear buckling.
  - Structural nonlinearities.
  - Static and dynamic kinematics analysis.
  - Thermal analysis.
  - Electromagnetic field analysis.
  - Electric field analysis.
  - Fluid flow analysis.
  - Coupled field analysis.
  - Computational fluid dynamics.
  - Pipe flow.
  - Piezoelectric analysis.

E. Structural Analysis
  - Structural analysis is probably the most common application of the finite element method. The term structural implies not only civil engineering structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts and tools.

F. Types of Structural Analysis:
  - Static analysis
  - Modal analysis
  - Dynamic analysis
  - Harmonic analysis
  - Transient analysis
  - Spectrum analysis
  - Buckling analysis

1. Static Analysis
   Static analysis, also called static code analysis, is a method of computer program debugging that is done by examining the code without executing the program. The process provides an understanding of the code structure, and can help to ensure that the code adheres to industry standards. Automated tools can assist programmers and developers in carrying out static analysis. The process of scrutinizing code by visual inspection alone (by looking at a printout, for example), without the assistance of automated tools, is sometimes called program understanding or program comprehension.

2. Modal Analysis
   Any physical system in nature can vibrate. The frequency at which vibration naturally occurs, and the modal shapes, which the vibrating system assume, are properties of the system, and can be determined analytically using modal analysis.

Modal analysis is the procedure of determining a structure dynamic characteristic, namely resonant frequency, damping values and the associated pattern of structural deformation called mode shapes. This analysis is performed while the test article is not running. Analysis of vibration modes is a critical component of design, which is often overlooked. The natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions.

3. Dynamic Analysis
   Fatigue analysis puts great demand on model accuracy. At the same time, the model cannot be too complex since dynamic analysis is time-consuming. Simplifications and idealizations have to be made without too much expansion solution accuracy. The Finite element method (FEM) yields an approximate solution. Meshes with deferent resolution should therefore be investigated to check for solution convergence.

   Determination of loads is a very important aspect since this is the actual source of fatigue failure. Several loading conditions must be determined, either by analytical approaches or experiments.

VI. Static and Fatigue Analysis Procedure

A. Problem Identification
   The present work deals with estimating the fatigue life of aluminum alloy wheel by conducting the tests under radial fatigue load and comparison of the same with that of finite element analysis. Fatigue life prediction using the stress approach is mostly based on local stress, because it is not possible to determine nominal stress for the individual critical areas. The necessary material data for fatigue life prediction with the stress concept is the well known S–N curve. Therefore, S–N curves are required for each specimen which reflects the stress condition in the critical area of the component.

   To find out the fatigue properties of the aluminum.

   In the fatigue life evaluation of aluminum wheel design, the commonly accepted procedure for passenger car wheel manufacturing is to pass two durability tests, namely the radial fatigue test and cornering fatigue test. Since alloy wheels are designed for variation in style and have more complex shapes than regular steel wheels, it is difficult to assess fatigue life by using analytical methods. In general, the newly designed wheel is tested in laboratory for its life through an accelerated fatigue test before the actual production starts. Based on these test results the wheel design is further modified for high strength and less weight, if required.

B. Procedure of the Fatigue Analysis Using Ansys

1. Wheel Specification
   - The specification of the wheel used in the project is as follows.
   - In the present work the designation of the wheel employed: 17" x 6
     
     \[
     \begin{align*}
     \text{Rim diameter} &= 13 \text{in} \\
     \text{Rim width} &= 4.5 \text{in} \\
     \text{Offset} &= 45 \text{mm} \\
     \text{PCD} &= 135 \text{mm} \\
     \text{Hub diameter} &= 100 \text{mm} \\
     \text{Profile} &= 17
     \end{align*}
     \]


2. Modal Description

The 3-dimensional modal of the wheel was created in CATIA and the file was exported in the IGES (international graphics exchange specification) format into ANSYS. The 3-dimensional modal that was developed is shown below.

3. Meshing of the Wheel

The mesh was meshed with 10-node tetrahedral structural solid elements. The wheel was meshed using an element edge length is 5mm. The total number of nodes and elements is 212319 and 117243 respectively. The finite element realization of the wheel obtained is shown in below.

The meshing was performed using the mesh generate option in the ansys workbench.

4. Boundary Conditions

The boundary constraints that were applied are that the wheel is fixed at the pitch circle diameter and hub portion in all degrees of freedom. i.e. the displacements of the wheel are constrained at the holes about the three directions x, y, and z. We are applying pressure radially on the wheel. The pressure is 2.8657 Mpa

5. Analysis

Fatigue analysis is used to determine the life, safety and damage of any component. The present work involves the determination of the life, safety factor and damage of alloy wheel and corresponding deformation, shear stress and alternative stress. In ansys workbench we had added tools of static analysis and fatigue tool.

C. Input for a Static and Fatigue Analysis in FEM

Table 1: Material Properties of A356.2

<table>
<thead>
<tr>
<th>Structural</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young’s Modulus</td>
<td>Thermal Conductivity</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>Specific Heat</td>
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<tr>
<td>Density</td>
<td>6.05e-002 W/mm·°C</td>
</tr>
<tr>
<td>Thermal Expansion</td>
<td>434. J/kg °C</td>
</tr>
<tr>
<td>Tensile Yield Strength</td>
<td></td>
</tr>
<tr>
<td>Compressive Yield Strength</td>
<td></td>
</tr>
<tr>
<td>Tensile Ultimate Strength</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Alternating Stress Vs Cycles

<table>
<thead>
<tr>
<th>Cycles</th>
<th>Alternating Stress MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>24076</td>
<td>234.12</td>
</tr>
<tr>
<td>34527</td>
<td>220.</td>
</tr>
<tr>
<td>51601</td>
<td>204.</td>
</tr>
<tr>
<td>77110</td>
<td>190.</td>
</tr>
<tr>
<td>1.1886e+005</td>
<td>175.59</td>
</tr>
<tr>
<td>1.8509e+005</td>
<td>160.</td>
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<tr>
<td>2.9425e+005</td>
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<tr>
<td>5.1319e+005</td>
<td>130.</td>
</tr>
<tr>
<td>8.7774e+005</td>
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<tr>
<td>1.7667e+006</td>
<td>100.</td>
</tr>
<tr>
<td>3.2e+006</td>
<td>87.76</td>
</tr>
</tbody>
</table>

Fig. 13: Alternating Stresses Vs Cycles

Table 3: Cycles Alternating Stress MPa

<table>
<thead>
<tr>
<th>Cycles</th>
<th>Alternating Stress MPa</th>
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<tbody>
<tr>
<td>24076</td>
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</tr>
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<td>190.</td>
</tr>
</tbody>
</table>

Fig. 14: Constant Amplitude Load Fully Reversed

VII. Conclusions

- Alloy wheels intended for use on passenger cars stipulate two types of fatigue tests, the dynamic cornering fatigue test and the dynamic radial fatigue test. As wheels undergo inconsistent, varying loads during their service life, fatigue behavior is a key consideration in the design and performance evaluation.
- Fatigue analysis is used to determine the life, safety and damage of any component.
- Maximum of Alloy wheels Compressive Yield Strength 250 MPa
- Maximum of Alloy wheels Tensile Ultimate Strength 279 MPa
- Life of Alloy wheels

References