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DESIGN AND DEVELOPMENT OF ALLUMINIUM ALLOY WHEELS

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ABSTRACT:

Wheels which are made from an alloy of aluminum or magnesium are Alloy wheels. They provide better heat conduction and improved cosmetic appearance over steel wheels and are typically lighter for the same strength. , To flat steel discs and stamped metal configurations and modern cast and forged aluminum alloys rims of today's modern vehicles are developed by automotive wheels over the decades from early spoken designs of wood and steel, carryovers from wagon and bicycle technology. For analyzing the stress and the displacement distribution in vehicle wheels subjected to conjoint influence of inflation pressure and the radial load this project work generalizes the application of Finite Element Analysis Techniques. The most commonly used considerations in Alloy wheels are illustrated. The analysis is carried out by using "ANSYS" and mscnastr finite element package, and the model is done by using "PRO/E". The wheel is modeled by using ten nodded tetrahedron solid elements; for the analysis of linear elastic with isotropic conditions the constitutive material model is selected. With the radial load on the stress and displacement in tire rims, through experimental stress analysis and finite element analysis, we examine the effects of tire air pressure in conjunction.

Keywords: Alloy wheels, Finite Element Analysis, static analysis.

INTRODUCTION:

The importance of wheel and tyres in the automobile cannot be challenged. Without engine, car may tow, but without the wheels, this is not possible. The wheel with tyres takes full load, and reduces friction, and provides cushioning effect to passenger by absorbing vibration due to road surface unevenness and assist in steering control. The alloy of conventional disc wheel in case of car and wire wheel as in case of motorbike has better aesthetic looks and easy of manufacturing.

The main requirements of an automobile wheel are;

1. It should be as light as possible so that unsprung weight is least
2. It should be strong enough to perform the above functions.
3. It should be balanced statically as well as dynamically.
4. It should be possible to remove or mount the wheel easily.
5. It material should not deteriorate with weathering and age .In case, the material is suspected to corrosion, it must be given suitable protective treatment.

Type of Wheel/Rim (Material)

Steel and light alloy are the main materials used in a wheel, and some of the composite materials are included such as glass-fiber are used for special wheels.

Light Alloy Wheel

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

Aluminum Alloy Wheel

Aluminum is a metal with features of excellent lightness, thermal conductivity, corrosion resistance, characteristics of casting, low temperature, machine processing and recycling, etc. They are typically lighter for the same strength and provide better heat conduction and improved cosmetic appearance over steel wheels. The earliest light alloy wheels were made of magnesium alloys .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.

Fig.1 Aluminum Alloy Wheel.

1. Wheel: Wheel is generally composed of Rim and Disc.
2. Rim: This is a part where the tyre is installed.
3. Disc: This is a part of the rim where it is fixed to the axle hub.
4. Offset: This is a distance between wheel mounting surface where it is bolted to hub and the centerline of rim.
5. Flange: The flange is a part of rim, which holds the both beads of the tyre.
6. Bead Seat: Bead seat comes in contact with the bead face and is a part of rim, which holds the tyre in a radial direction.
7. Hump: It is bump what was put on the bead seat for the bead to prevent the tyre from sliding off the rim while the vehicle is moving.
8. Well: This is a part of rim with depth and width to facilitate tyre mounting and removal from the rim.

BENEFITS OF FITING OF ALLOY WHEELS:

A set of alloy wheels will improve the appearance of our vehicle and by doing this will make our vehicle stand out from the crowd. Alloy wheels will reduce unsprung weight of a vehicle fitted with standard steel wheels. The benefit of reduced unsprung 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.When selling alloy wheels applying the “inch up principle”, there is an improvement in the steering response and road holding, especially when cornering.

FINITE ELEMENT ANALYSIS

The Finite Element Technique produces many simultaneous algebraic equations, which are generated and solved on a digital computer. The Finite Element Method originated as a method of stress analysis. The Finite Element Method is firmly established as a powerful and popular analysis tool. It is a numerical procedure for analyzing structures and continua. Finite element procedures are used in design of buildings, electric motors, heat engines, ships, airframes and spacecrafts. The Finite Element Method, in general, models a structure as an assemblage of small elements. FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. 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. FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. . In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition. FEA uses a complex system of points called nodes, which make a grid called a mesh. This mesh is programmed to contain the material and structural properties, which define how the structure will react to certain loading conditions.

FATIGUE ANALYSIS

Fatigue is an important consideration for components and structures subjected to repeated loadings, and are one of the most difficult design issues to resolve. Experiment has shown that large percentage of structural failure are attributed to fatigue and as a result, it's an area which has been and will continue to be the focus of both fundamental and applied research.

Related loadings of a component or structure at stresses the design allowable for static loadings may cause a crack or racks to form. Under cyclic loading these cracks may continue to grow and precipitate a failure. When the remaining structure can no longer carry the loads. The mechanism of crack formation and growth is called fatigue.

The dramatic examples of fatigue failures include first two cornet jet aircraft and point pleasant 'silver bridge' which cause numerous fatalities and significance property damage, because of many service failures, the design of components and structures subjected to repeated loadings must consider fatigue performance. The appropriate definition is the tendency of a material to break under repeated cyclic loading at a stress considerer less than the tensile strength in a static test.

MATERIAL INTRODUCTION

A mathematical model of the low-pressure die casting process for the production of A356 aluminum alloy wheels has been developed to predict the evolution of temperature within the wheel and die under the auspices of collaborative research agreement between researchers at the University of British Columbia and North American wheel casting facility. The heat transfer model represents a three-dimensional, 30◦ slice of the wheel and dies; It was developed within the commercial finite-element package, ABAQUS. Extensive temperature measurements in the die and wheel taken over several cycles in the casting process were used to develop key process boundary conditions and validate the model. With the maximum difference less than 20 ◦C at the majority of locations, the anticipated and measured temperatures agree very well. A heat flux analysis conducted with the model has identified the complex path that the heat follows within the die and wheel during the solidification process.

FATIGUE ANALYSIS USING FEA PACKAGE:

A simple methodology to predict crack initiation life is described in the fatigue damage assessment of metallic structures typically used in ground vehicle industry. A phenomenological constitutive model is integrated with a notch stress–strain analysis method and local loads under general multiaxial fatigue loads are modeled with linear elastic FE analyses. The computed stress–strain response is used to predict the fatigue crack initiation life using effective strain range parameters and two critical plane parameters.

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. 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. In recent years, FEA has been used almost universally to solve structural engineering problems. One discipline that has relied heavily on this technology is the Automotive and Aerospace industry.

Due to the need to meet the extreme demands for faster, stronger, efficient and light weight Automobiles and Aircrafts, manufactures have to rely on the Technique to stay components and the high media coverage that the Industry is exposed to, Automotive and Aircraft companies need to ensure that none of their components fail, that is to cease providing the FEA has been used routinely in high volume production and manufacturing Industries for many years.

STATIC & FATIGUE ANALYSIS PROCEDURE

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.

In the fatigue life evaluation of aluminum wheel design, the commonly accepted procedure for passenger car wheelm 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.

Wheel Specifications	
Rim diameter	431.8mm
Rim width	152.4mm
Offset	45m
PCD	100m
Hub diameter	135m
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Table 1. Properties of material (A356.2)

The specification of the wheel used in the project is as follows. In the present work the designation of the wheel employed:17*6.

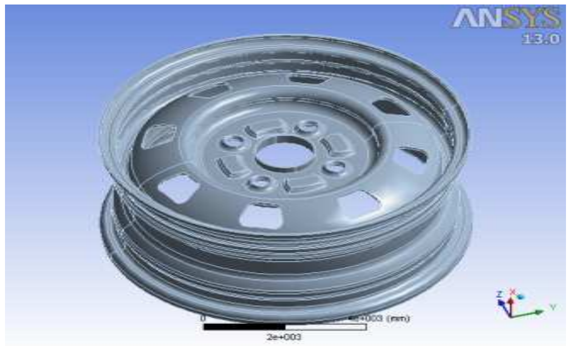

Diagram of aluminum wheel. 3-diemensional modal of the wheel was created in CATIA and the file was exported in the IGES (international graphics exchange specifications) format into ANSYS.

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 is212319 and 117243 respectively.

RESULTS AND DISCUSSIONS

In Table 1 and Table 2 properties of the material and alternating stress vs cycles is given. Also it is graphically denoted in Fig .4.

After completion of meshing we apply pressure 2.8653 Mpa at rim . The total deformation of wheel maximum is 0.2833mm and minimum is 0.031478 at hub portion.

The alloy wheel of shear stress maximum is 48.195 and minimum is -48.241 at hub. The equivalent stress is 163.97 and 0.038. The life of wheel maximum 1.7667e6 cycles and the minimum cycles of wheel is 1.6533e5 at a cross sectional area of wheel.

The wheel safety maximum at a hub portion because the load is maximum acting at a rim. Minimum load is acting at a hub. The damage of wheel high at a cross sectional area of wheel spokes. Finite element analysis is carried out by simulating the test conditions to analyze stress distribution and fatigue life, safety and damage of alloy wheel.

The S–N curve approach for predicting the fatigue life of alloy wheels by simulating static analysis with cyclic loads is found to converge with experimental results. Safety factors for fatigue life and radial load are suggested by conducting extensive parametric studies.

The proposed safety factors will be useful for manufacturers/designers for reliable fatigue life prediction of similar structural components subjected to radial fatigue load. By using ANSYS we determine the total deformation and stresses developed in a alloy wheel.

Table 2: Alternating Stress Vs Cycles

Cycles	Alternating Stress MPa
24076	234.12
34527	220.
51601	204.
77110	190.
1.1886e+005	175.59
1.8509e+005	160.
2.9425e+005	146.32
5.1319e+005	130.
8.7774e+005	117.06
1.7667e+006	100.
3.2e+006	87.76

Fig.4 constant amplitude fully reversed load is given.

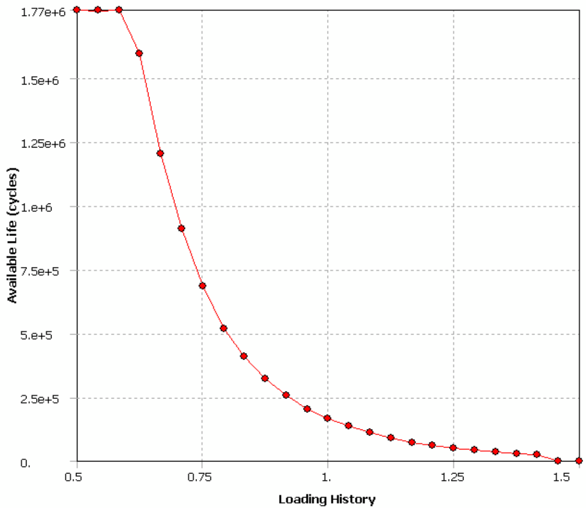

Figure 4. Life & Load

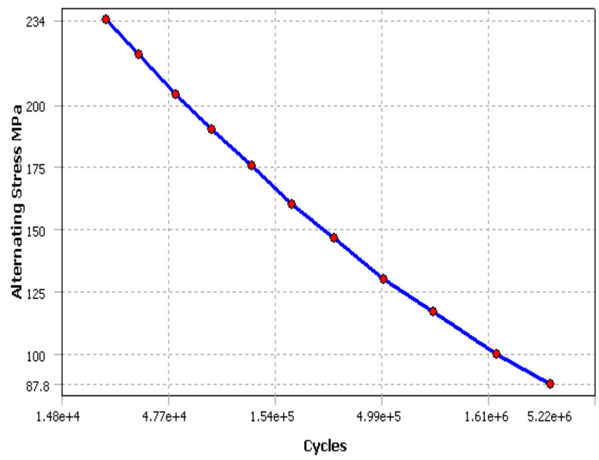

Figure 5 . Alternating Stress vs Cycle

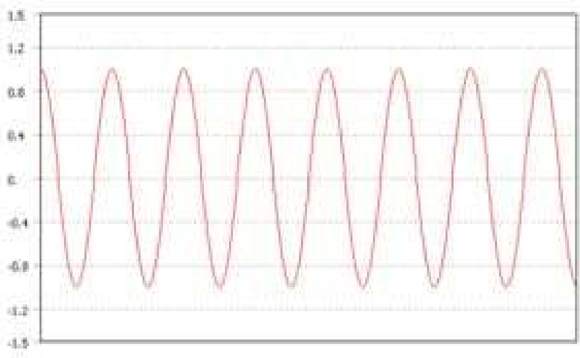

Figure 6. Constant amplitude fully reversed

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