DESIGN AND ANALYSIS OF WHEEL HUB

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Abstract : In this project various methodologies adopted by present researcher for analysis of Wheel hub and upright assembly with main objective of analysis and optimization of the vehicle. This review will assist researchers working in the field of development of the structural design and mass reduction of vehicle through optimization methods conducted by FEA software viz. Catia V5 R19 and Analysis (workbench 16). The review includes key areas of researches as shape optimization, static load analysis and fatigue load analysis using FEA. This literature progressively discusses about the research methodology, software's and the outcomes of the discussed researches and is intended to give a brief variety of the researches carried out on the wheel hub and upright assembly.

Key Words: WHEEL HUB, TYPES OF MATERIAL, STATIC ANALYSIS.

1.INTRODUCTION

Wheel hub and upright assembly is a very critical part of the vehicle suspension system which allows the steering arm to turn the front wheels and support the vertical weight of the vehicle. Upright is also known as the knuckle. It assembles with the front tire and a spindle that rotates in a stable plane of motion by a suspension assembly . The force exerted on hub and upright assembly are of the cyclic nature as the steering arm turned. To have the maximum speed for the sports car the weight has to be minimized, therefore while designing the sports car the designers keep this as key factor and design the vehicle for minimum weight and maximum stress and force sustaining ability. The design of wheel hub and upright are one of the important parameters in optimizing the weight of the vehicle. The mass reduction without compensating the strength of the wheel hub and upright assembly is done by the researchers to optimize the weight of the vehicle. Weight or mass of the vehicle can be reduced by improving technology such as material selections, design and analysis method and optimization method. Steering upright subjected to time varying load during service life, leading to fatigue loads. The hub and upright assembly also transfers the whole weight of the vehicle into wheels, which lead to stress on mountings.

Wheel hub and upright can be analysed without due consideration to bearing design. In automotive suspension, a steering upright is that part which contains the wheel hub or spindle, and attaches to the suspension components, variously it is known as steering knuckle, spindle, upright or hub The wheel and tire assembly attach to the hub or spindle of the knuckle where the tire/wheel rotates while being held in a stable plane of motion by the knuckle/suspension assembly. of double- wishbone suspension, the knuckle is attached to the upper control arm at the top and the lower control arm at the bottom. The wheel assembly is shown attached to the knuckle at its centre point. Suspension systems in any vehicles uses different types of links, arms, and joint to let the wheels move freely , front suspensions also have to allow the front wheel to turn. Steering knuckle/spindle assembly, which have two separate or one complete parts attached together in one of these links. Hub is the part attached to upright, the purpose of a wheel hub is to attach a wheel to a motor shaft.

2. PROBLEM STATEMENT

Our previous car utilized wheel hub made of mild steel. Mild steel provided strength to hub against bending during cornering and bump situations and resisting against torsion during braking. The total mass of the wheel hub excluding the bearing was kg, which consisted of % of our total cars mass. Although the previous design has worked very well in terms of strength but it had following major issues which became important design points for the future design:

- The wheels hubs were very heavy
- The brake rotors once fixed could not be removed if in case it so damaged.
- The outer diameter was large which restricted us to use bearing of larger dimension adding more weight.

So I am doing the project of design the wheel hub of for material optimization. That the project to find the optimal design for hubs. The team only did basics calculation for do the first design in the hubs, but they want know more about the real work of it. In the first point, the team want know when the current hubs will break, because that pieces need support a number of cycles and they wouldn´t like that pieces break in the middle of the race. Known if parts endure or not endure this number of cycles, the parts are manufactured adapted to the required needs. With some calculus and with CATIA and ANSYS, it's possible to solve this problem.

3. LITERATURE REVIEW

[1] Kaixian Yue,

This paper concluded that the three kinds of acceleration models for the accelerated life testing for fighter-bomber wheel hubs corresponding to three kinds of SCF are built, and t-test is used to estimate the relation among them. When the significance level is set as 0.02, the three acceleration models are equivalent, which suggests that the acceleration factor for fighter-bomber wheel hubs made by 2014Al is not sensitive to SCF. the fatigue life tests of 2014 aluminum alloy, which is extensively used to make fighter-bomber wheel hubs. The BLUE (best linear unbiased estimation) and MLE (maximum likelihood estimation) are adopted in the estimation of the acceleration models, and the acceleration models under the conditions of different SCF (stress concentration factor) are compared by statistical method to determine the sensitivity of SCF to the acceleration factor of the fighter-bomber wheel hubs made by 2014Al.

[2] M. Amura , L. Allegrucci, F. De Paolis, M. Bernabei ,

This paper concluded that the forged 2014-T6 aluminium alloy main wheel of an AMX aircraft failed during pre-flight taxiing. Failure occurred on the wheel housing hub and its origin was located on the interior edge of the bearing cup housing. The wheel experienced high cycles fatigue. A plastic deformation was produced during the wheel mounting operations caused an abnormal stress concentration. It has been identified as cause of a progressive fracture mechanism. Consistent optical, metallographic and electron microscopy evidences were collected. Moreover, Finite Element Analysis (FEA) demonstrated that the observed defects produced the stress level needed to fatigue to initiate. Recommendations were issued in order to improve the Non-Destructive Techniques (NDT) used to monitor the wheel structural integrity. Laboratory tests showed that ultrasounds in this case would be far more efficient than the prescribed eddy currents.

[3] Kazem Reza Kashyzadeh, Mohammad Jafar Ostad-Ahmad-Ghorabi , Alireza Arghavan

this paper concluded that the fatigue testing which is one of the most signi - cant ones. Another issue is the high cost in practical ways, and to cope with this issue various ways must be assessed and analyzed, one of the best and the most e¢ client ways is modeling and testing in virtual soft- ware environments. In the present paper, predict fatigue life of suspension component and package of automotive suspension are the main purposes. First, using MATLAB software, road roughness according to the intercity roads for constant vehicle velocity (100Km/h) has been studied. After that frequency response of components has been analysed, its critical points determined to calculate the fatigue life of the part, and the amount of critical stress obtained based on Von Misses, Tresca and Max Principle criterion for a quarter car model (passive suspension System in 206 Peugeot). Fatigue life of the vehicle components are calculated in terms of kilo-Meters in specialized fatigue software such as 116944, 92638.9, 46388.9 and 191388.9 Km respectively wheel hub, pitman arm, suspension arm and package of suspension. Finally, to prove the given results of the nite element method compared with reported results by other researchers and the results match very well with those.

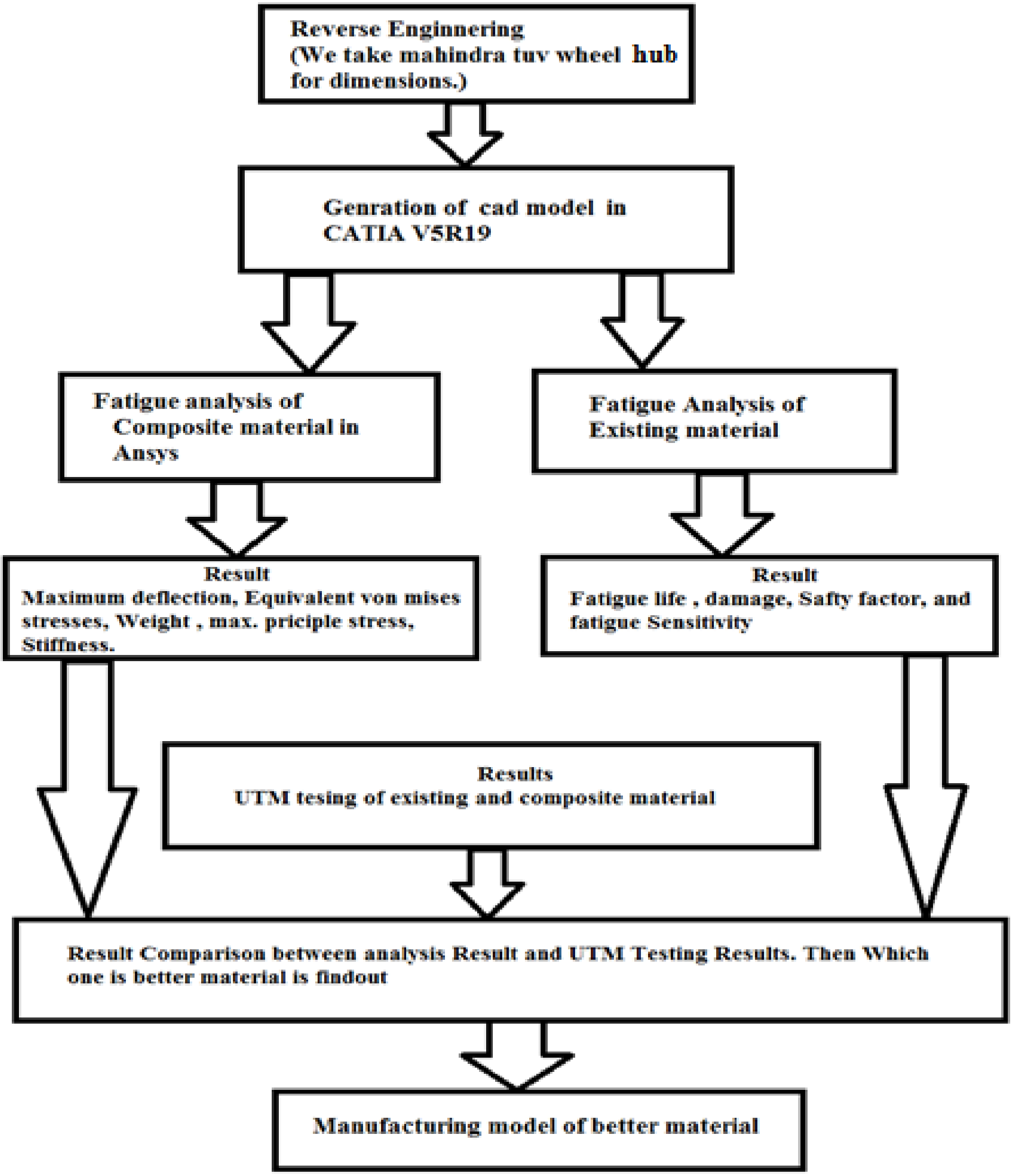
[4] J. Janardhan, V. Ravi Kumar, R. Lalitha Narayana

this paper concluded that the vehicle (car) may be towed without the engine but at the same time even that is also not possible without the wheels, the wheels along the tyre has to carry the vehicle load, provide cushioning effect and cope with the steering control. The main requirements of an automobile wheel are; it must be strong enough to perform the above functions. It should be balanced both statically as well as dynamically. It should be lightest possible so that the un-sprung weight is least. The Wheel has to pass three types of tests before going into production, they are Cornering fatigue test, Radial fatigue test and Impact test. In this thesis radial fatigue analysis is done to find the number of cycles at which the wheel is going to fail. The 2D of the wheel was created in MDT, the drafting package and the same was exported to ANSYS, the finite element package using IGES translator where the 3D model of the wheel is created. The wheel is meshed using SOLID 45 element. A load of 2500N was applied on the hub area of the wheel and a pressure of 0.207N/mm2 is applied on the outer surface of the rim. The pitch circle holes are constrained in all degrees of freedom. The analysis is carried under these constraints and the results are taken to carryout for further analysis i.e. fatigue module to find the life of the wheel.

[5] Malapati.M, K V S Karthik

This paper concluded that the hub is one of the main parts of automobile wheel that is mounted on the center to wheel. When the axle rotates along with it the wheel hub also rotates. While the vehicle is running, the wheel is affected by different loads and stresses at different temperatures. Generally hubs are made up of ductile iron and aluminum. As we know that the strength and weight of ductile iron is more when compare to aluminum. This research paper describe that Critical parameters such as stress, ultimate tensile stress, % elongation and hardness at different points on the both ductile iron hub and aluminum hub is evaluated by commercial analysis software ANSYS and experimental way with a suitable material for wheel hub. The theoretical critical parameters such as stress, ultimate tensile stress, % elongation and hardness at different points were compared with experimental critical parameters values of each material. Hence the deviation of critical parameters is below 10% so that the analytical values of critical parameters are experimentally proved its correctness.

4. METHODOLOGY



5. CALCULATONS

Calculation of wheel hub:

Braking Torque:

Brake pedal force:

Breaking Torque	230 N-m

The Brake applied on the pedal is assumed to be 300 N (30.6 kgf)

1. Pedal ratio of every 4 wheeler is 6:1
2. f_{max} = force × pedal ratio

= 294.3 ×6

= 1800 N

Where,

f_{max} = force applied onto the master cylinder)

Hence, $P = \frac{fmax}{(\frac{\pi}{4}) \times d2}$

(P =hydrostatic pressure, d = diameter of master cylinder's piston)

$Fmax = P \times \frac{\pi}{4} \times D^2$ [by Pascal's Law]

(Fmax = force acting on each Cylinder, D = diameter of the piston Cylinder in the caliper)

By Solving,

$Fmax = f_{max} \times (\frac{D}{d})^2$

$= (1800) \times (0.03 / .019)^2$

= 4487.53 N

Torque acting on the disc:

T = Fmax × μ × Re × number of pistons per caliper

= 4487.5346 ×0.3 × 0.097 ×3

= 391.76N-m

μ = Coefficient of friction between brake pad and disc (0.3)

Re = Radius of the disc.

Max velocity of Vehicle = 156 kmph.

Mass of the vehicle=2225kg

From Newton's second law of motion: F = m × a

Here,

F= 2225 × 9.81

F= 21827.25 $\frac{kgm}{s^2}$ (N)

F= 21827.25 N

Force Applied on each Wheel

$= \frac{F}{4}$

$= \frac{21827.25}{4}$

F = 5456.8125 N

6. FIGURE AND TABLE

FIG: WHEEL HUB

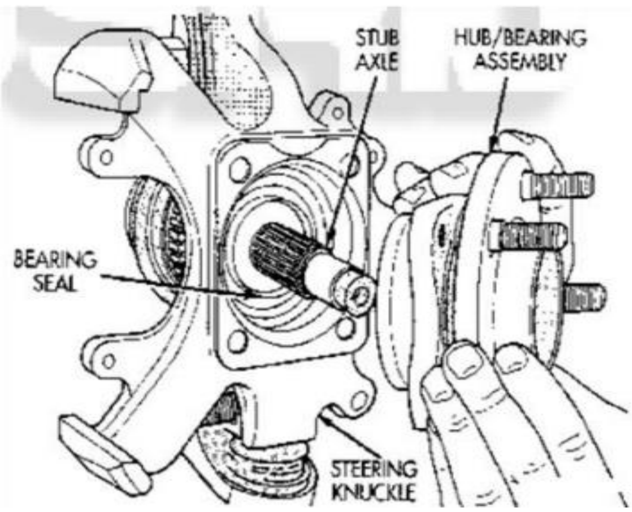


FIG: ASSEMBLY OF WHEEL HUB

Sr. No.	Description	Mass (kg)	Deflection(mm)	Von-Mises stress (MPa)
1	Carbon Fiber Moment + Bump Moment + Corner Force	0.34701 0.34701	0.20183 0.22586	126.92 163.34
2	Cast Iron Moment + Bump Moment + Corner Force	1.6786 1.6768	0.020217 0.02328	89.137 129.71
3	SS Moment+ Bump Moment + Corner Force	1.8049 1.8049	0.011768 0.013496	92.779 134.65

7. Conclusion

From finite element analysis it is observed that Stainless steel is a better option for Wheel Hub giving a better Stress than hub and in turn reducing the strength of hub. We will be Proceeding for fabrication of hub for Stainless Steel hub.

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