Manufacturing Process of Wheel Hub

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ABSTRACT

The paper represents the behavior of wheel hub subjected to different loads for different materials. It gives an insight to various options that can be used for wheel hubs and compare the different materials with each other. The wheel hub presently of cast iron is compared with three different materials viz. Al alloy, SS, Mg alloy. The effect of bump force, braking torque and cornering force are considered in the analysis. The output stress for all the four materials are then utilized to calculate the fatigue life of wheel hub using the Goodman equation. The paper represents the step by step manufacturing process of wheel hub.

Keywords : Wheel hub, Al alloy, manufacturing

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I. 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 analyzed 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.

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.

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.

Images of failure:


Fig 1. Crack near the hub

II. LITERATURE SURVEY

[1] Kaixian Yue, this paper concluded that thethree 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 cuphousing. The wheel experienced high cycles fatigue. A lastic 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¢ cient ways is modelling 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 de- termined 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). Fa- tigue 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 unsprung 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

[6] Mehmet Firat , Recep Kozan, Murat Ozsoy, O. Hamdi Mete , this paper concluded that the fatigue damage assessment of metallic automotive components and its application is presented with numerical simulations of wheel radial fatigue tests. The technique is based on the local strain approach in conjunction with linear elastic FE stress analyses. The stress–strain response at a material point is computed with a cyclic plasticity model coupled with a notch stress–strain approximation scheme. Critical plane damage parameters are used in the characterization of fatigue damage under multiaxial loading conditions. All computational modules are implemented into a software tool and used in the simulation of radial fatigue tests of a disk-type truck wheel. In numerical models, the wheel rotation is included with a nonproportional cyclic loading history, and dynamic effects due to wheel–tire interaction are neglected. The fatigue lives and potential crack locations are predicted using effective strain, Smith–Watson–Topper and Fatemi–Socie parameters using computed stress–strain histories. Three-different test conditions are simulated, and both number of test cycles and crack initiation sites are estimated. Comparisons with the actual tests proved the applicability of the proposed approach.

III. METHODOLOGY

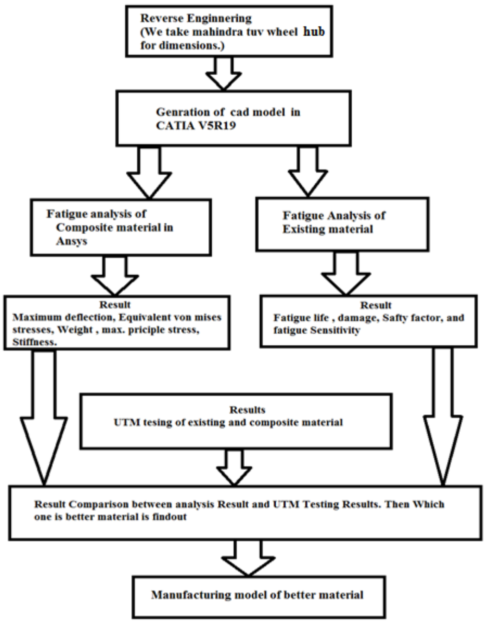

Fig 2. Proposed methodology

IV. FLOW OF PROCESS

The following flow chart shows the step by step operations carried out on the wheel hub from raw material to finished product done on the conventional machines as shown in Fig 3:

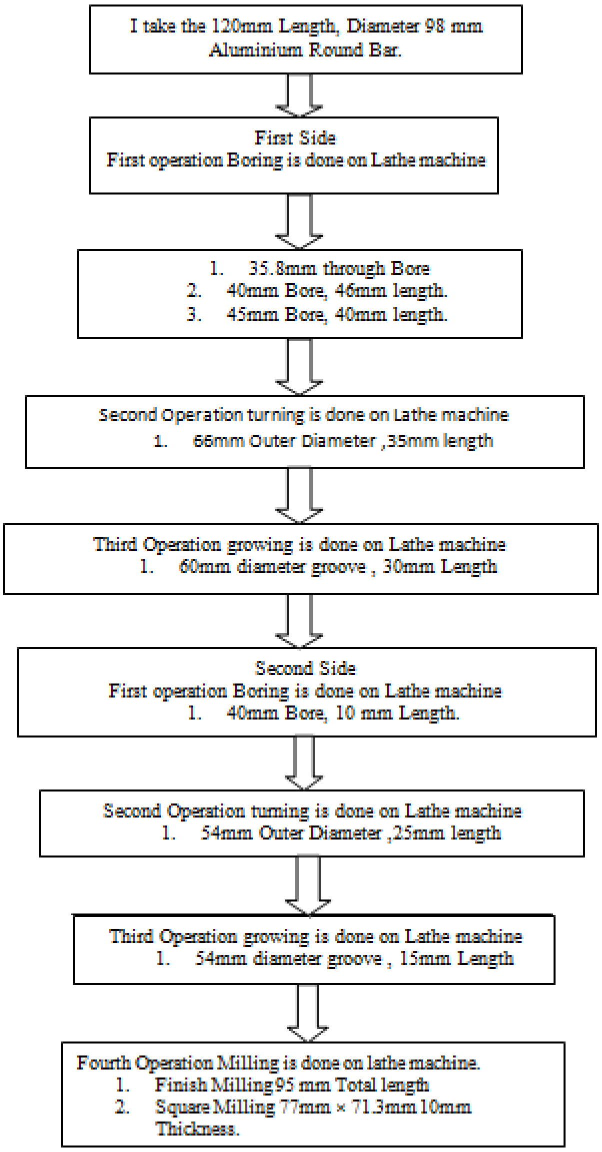

Fig 3. Proposed flow

V. MANUFACTURING PROCESS

Operations used for fabrication

1. **Raw materials:** A raw material is the basic material used in the productions of the goods, finished products. The term "raw material" is used to denote material which is unprocessed.

2. **Marking:** Marking is the process of making visible impressions on the metal surface so that required operations can be carried out as per the dimensions

Factors Determining The Selection Of Materials

The various factors which determine the choice of material are discussed below.

Properties

The material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environmental attack from chemicals, service life, reliability etc.

The following four types of principle properties of materials decisively affect their selection

- Physical
- Mechanical
- From manufacturing point of view
- Chemical

The various physical properties concerned are melting point, thermal Conductivity, specific heat, coefficient of thermal expansion, specific gravity, electrical conductivity, magnetic purposes etc. The various Mechanical Properties Concerned are strength in tensile, Compressive shear, bending, torsion and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit, and modulus of elasticity, hardness, wear resistance and sliding properties. The various properties concerned from the manufacturing point of view are:

- Cast ability
- Weld ability
- Surface properties
- Shrinkage
- Deep drawing etc.

Manufacturing Cost

Sometimes the demand for lowest possible manufacturing cost or surface qualities obtainable by the application of suitable coating substances may demand the use of special materials.

Quality Required

This generally affects the manufacturing process and ultimately the material. For example, it would never be desirable to go casting of a less number of components which can be fabricated much more economically by welding or hand forging the steel.

Availability Of Material

Some materials may be scarce or in short supply, it then becomes obligatory for the designer to use some other material which though may not be a perfect substitute for the material designed. The delivery of materials and the delivery date of product should also be kept in mind.

Space Consideration

Sometimes high strength materials have to be selected because the forces involved are high and space limitations are there.

Cost Estimation

Cost estimation may be defined as the process of forecasting the expenses that must be incurred to manufacture a product. These expenses take into a consideration all expenditure involved in a design and manufacturing with all related services facilities such as pattern making, tool, making as well as a portion of the general administrative and selling costs.

Purpose Of Cost Estimation

1. To determine the selling price of a product for a quotation or contract so as to ensure a reasonable profit to the company.
2. Check the quotation supplied by vendors.
3. Determine the most economical process or material to manufacture the product.
4. To determine standards of production performance that may be used to control the cost.

Types Of Cost Estimation

1. Material cost
2. Machining cost

Material Cost Estimation

Material cost estimation gives the total amount required to collect the raw material which has to be processed or fabricated to desired size and functioning of the components. These materials are divided into two categories.

1. Material for fabrication:

In this the material in obtained in raw condition and is manufactured or processed to finished size for proper functioning of the component.

2. Standard purchased parts:

This includes the parts which was readily available in the market like allen screws etc. A list is forecast by the estimation stating the quality, size and Standard parts, the weight of raw material and cost per kg. For the fabricated parts.

Machining Cost Estimation

This cost estimation is an attempt to forecast the total expenses that may include manufacturing apart from material cost. Cost estimation of manufactured parts can be considered as judgment on and after careful consideration which includes labour, material and factory services required to produce the required part.

Procedure For Calculation Of Material Cost

The general procedure for calculation of material cost estimation is after designing a project,

1. A bill of material is prepared which is divided into two categories.
   a. Fabricated components
   b. Standard purchased components
2. The rates of all standard items are taken and added up.
3. Cost of raw material purchased taken and added up.

Safety Precautions

The following points should be considered for the safe operation of machine and to avoid accidents:-

1. All the parts of the machine should be checked to be in perfect alignment.
2. All the nuts and bolts should be perfectly tightened.
3. The operating switch should be located at convenient distance from the operator so as to control the machine easily.

4. The inspection and maintenance of the machine should be done from time to time.

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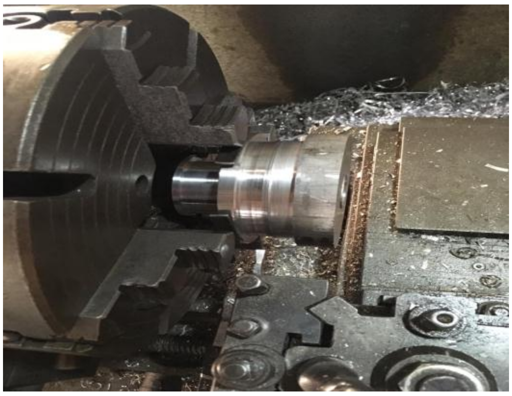
VI. MACHINE IMAGE

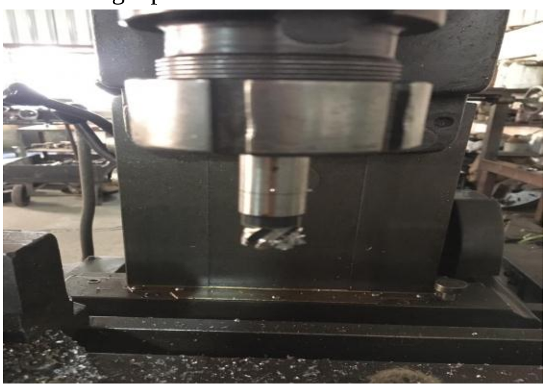
1. Boring Operation

2. Turning Operation

3. Grooving Operation



4. Milling Operation:



VII.FINAL PRODUCT

Fig. Top View

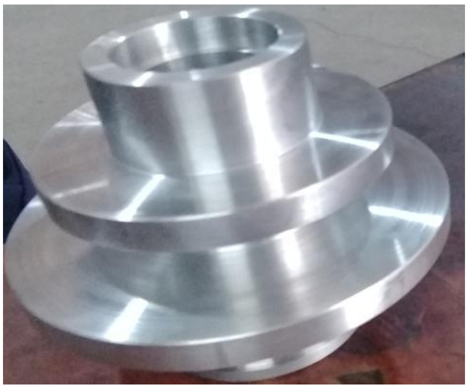


Fig. Side View

VIII. CONCLUSION

This work has provided a comprehensive methodology review of manufacturing the wheel hub and the step by step operations carried for the fabrication of wheel hub of aluminium alloy with the help of conventional machines.

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