Design Modeling and Analysis of Steering Upright

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***Abstract*— A steering upright is one of the vital components in vehicle dynamics which links all suspension components between the wheel and therefore the vehicle. Upright provides the linkage between the upper & lower ball joints. The upright connects components as an example, control arms, steering arms, suspension springs, shock absorber, brake disc, wheels & tire. Steering upright is a part of mechanical system which contains the wheel hub and assembles to the suspension components. It's the pivot point of the steering and mechanical system, which allows the front wheels to show & more. Agenda of this project paper is to design & analysis of steering upright and study the scope of further optimization work, experimental validation to achieve weight reduction along with required strength and stiffness. Optimized design of upright is necessary with correct material selection further as valid finite element analysis. Optimization is accomplished considering static stress, strain and total deformation analysis with acceptable material selection. Modal and Fourier analysis is to be performed to see natural frequencies and deformation.**

***Index Terms*— Steering Upright, CATIA V5, 3D Modeling, 2D Drawing, ANSYS 19**

I. INTRODUCTION

In the automobile sector robust and comfortless of the system is that the most significant thing. The auto should maintain the comfort not only on the standard roads but also on off roads too. For that purpose a high quality steering mechanism is most significant thing, because it won't just absorb the vibrations but also supports the full system. Steering upright is the part which accommodates the wheel hub or spindle, and links to the suspension and steering components. It's variously called a steering knuckle, spindle, upright or hub also .The knuckle is attached to the upper control arm at the very best and so the lower control arm at the lowest.

In a non-drive suspension, as shown within the primary photo, the knuckle usually features a spindle onto which the drum or brake rotor attaches. In an exceedingly drive suspension, the knuckle has no spindle, but rather features a hub into which is affixed the bearings and shaft of the drive mechanism. The top of the drive mechanism would then have the specified mounting studs for the wheel/tire and/or brake assembly. During this automotive and competitive era the need for light-weight weight structural materials is increasing as there's an additional think about fuel consumption reduction and improvement in decreasing the emission. The magnitude of production volumes has historically placed severe necessities on the robustness of method employed within the manufacturing. The manufacturers have strong importance on the value has the demand for the component to reinforce the fabric performance and to deliver these materials at low cost is that the requirement.

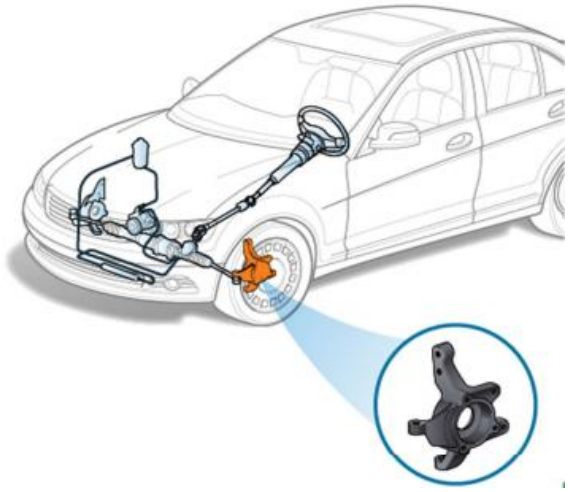

FIG 1: Steering mount assembly

The steering knuckle is that the pivot point of the mechanism, which allows the wheels to revolve. Generally on automobile vehicle with conventional suspension systems, the steering knuckle's spindle locates and supports the inner and outer wheel bearings. Upright is also a part of the wheel assembly

which holds the hub and allows rotation of the wheel. Forces from the tire's contact patch are conveyed by the upright to the suspension linkages. Hence the steering upright should have that much of strength in such a fashion that it mustn't fail in off road conditions because the terrain is incredibly difficult and its function isn't to only support the auto but also to transfer the steering motion to the wheels coming from mechanism. So there's a high possibility of failure thanks to the sudden stress generation and resonance. Even slight damage of the steering knuckle can affect the correct wheel alignment and disturb the stableness of the vehicle. Therefore this component should be manufactured with high precision and sturdiness.

II. LITERATURE REVIEW

Mahesh P. Sharma et al. [1] In these paper Steering knuckle is one of the important component which connects to steering, suspension and brake to chassis of auto. It undergoes different loading under various conditions. In this paper static analysis of steering knuckle was done. Knuckle was designed which accommodates twin caliper mountings to improve braking efficiency & reduce stopping distance of a car. During this investigation, steering knuckle was used as component for study. Main design and functionality of steering knuckle depends on variety of suspension implemented. Additional factors like brake caliper, steering sub-system rod mounting also effects knuckle design. To result maximum stress and deformation of steering knuckle when different forces like braking force, load transfer during acceleration and braking etc. are applied thereon static analysis is performed. Structural optimization tools like topology and shape optimization alongside manufacturing simulation have gotten attractive tools in product design process. These tools also help to reduce development time. Shape optimization gives the optimum fillets and thus the optimum outer dimensions.

V.Sivananth et al. [2] Simulation and analysis of components are executed in automobile plant, so as to cut back the quantity of prototype during experimental validation. During this study, CAD model of steering knuckle was developed using modeling package SOLIDWORKS. While vehicle in a motion, the load generated at tire road contact patch would be transferred to the knuckle and its surrounded parts. The load transfer varies relation to various driving condition such as cornering, acceleration, braking, bump, static pot hole etc. will severely affect its fatigue life. It's been noticed from knuckle manufacturers that material and geometric optimization is that the real need for the automobile industry to reduce weight of the knuckle without affecting the performance. Static analysis was performed on three load cases and the results were compared for SG iron and Al alloy.

Gaurav Saxena et al. [3] This paper carries different methodologies adopted by researcher for wheel hub and upright assembly analysis with main goal of study & optimization on vehicle. This review assists researchers working within the sphere of development of structural design and mass reduction of auto by optimization method conducted through FEA software viz. Creo 1.0 and Hyper Works. In Wheel hub and upright assembly may be a very critical a part of the vehicle suspension which allows the steering arm to indicate the front wheels and support the vertical weight of the vehicle. Upright is additionally referred as the knuckle.

Saksham Bhardwaj et al. [4] Steering upright is a part of suspension system which contains the wheel hub, and attaches to the suspension components. It is the pivot point of steering and suspension aggregate, which allows the front wheels to turn. Considering it for double wishbone suspension geometry, lightweight & low fuel consumption are fundamental requirements for vehicle, especially for racing car. This paper focus on design optimization of steering upright/ knuckle target to induce weight reduction with required strength and stiffness. Our project provides two paths to realize identical goals of weight reduction, one which needs only a few resources and hence the other requires several resources. First approach of intuition shall be used for low budget study by compromising a bit on the burden and increasing the target Factor of safety.

Mahendra L. Shelar et al. [5] In these journal it presents the foremost important issue in vehicle industry is that the existence of differences within the physical properties and manufacturing methodologies. Deterministic approaches are incapable to into account these variability's without leading to oversized structures. The requirement of assessing the robustness of a particular design

requires a method supported strength and elegance optimization through probabilistic models of design variables (DOE). Generally, it's identified the steering knuckle which is one amongst the critical components of auto which links suspension, steering system, wheel hub and brake to the chassis. In these journal author have identified the above problem strategy of optimizing the planning employing a strategy supported durability and elegance optimization through probabilistic models of design variables (DOE). When comparing the optimized model with the initial version, 9.19% weight has been reduced with acceptable stress and deflection change and not crossing the project target limits.

III. PROBLEM STATEMENT

Steering upright is used for transmission of motion from steering system to the wheels. They're assembled by using the kingpin, and connected to both the lower control arm and upper control arm. Their assembly is completed in such a manner that the vibrations transmitted from them will get absorbed by the suspension, that they're directly in touch with the tires. Hence there's a high chance of failure due to the sudden application of load and because of the formation of resonance. Their weight is high hence there's chance of generation of inertia forces and unnecessary material usage.

IV. OBJECTIVES OF PROJECT

To reach a suitable counter-measure of the stated problem, study and analysis of a steering upright is to be done by finite element analysis. Further optimization needs to be completed to meet the allowable weight reduction and overcome the vehicle failure.

Below strategies are to be obtained in two parts.

First Part will follow;

- Modeling of existing Steering Upright using CATIA V5 R20 software.
- Perform Static & dynamic analysis to determine von misses stress and deformation using ANSYS.
- Topology Optimization

Second part will follow;

- Design & Weight optimization by material removal.
- Validation of the Experimental testing and correlating results.

V. METHODOLOGY

Step1:- Literature survey and Component finalization.

Step2:- 3D Model drafting with the help of CATIA V5.

Step3:- Modal & Harmonic analysis of component by ANSYS uses FEA.

Step4:- The Experimental Testing will be carried out.

Step5:- Comparative analysis between the experimental & analysis result to draw the final conclusion.

VI. CAD MODELING

In automobile sector, different type of materials are used for the manufacturing of steering upright like grey cast iron, white cast iron, S.G iron etc.

It contains the Brake Caliper mounting point, Steering tie rod mounting, Suspension upper and lower ball joint. Generally the upright part design depends on suspension and steering system geometry.

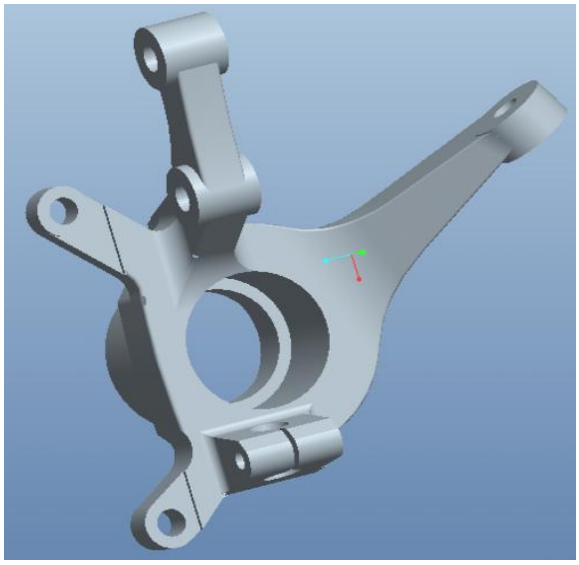

FIG. 2: CATIA model of existing steering upright

VII. FUTURE SCOPE

This first part of the paper covers the study of functional requirement and problem severity in a

vehicle. With continuation of current scope, steering upright model is to design considering specific material and weight in reference with existing Sumo vehicle. In further scope of work we process for the finite element analysis to obtain the allowable stress, strain and total deformation. According to the targeted result we will further execute the modal analysis and topology optimization. After analyzing the optimization we will get the amount of weight reduction with required stiffness & strength. Later on we will eliminate same amount of material from the actual part to overcome the above stated problem statement.

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