Static Structurals Analysis & Optimization of Concept Automotive A-arm

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Abstract- *The suspension control Arm is an intermediary with the suspension system, has a major function to cope with. The wheel base on one end and the connection to the chassis member exposes the part to high stresses while performing its function. This would help the design team to redesign the part for safe operation while aiming for adequate strength for addressing the function. There are many types of the suspensions like wishbone or double wishbone suspensions. Many times it is also called as A-type Suspension control arm. In this study Lower control arm observed by reverse engineering. Reverse engineering consist of process of making the CAD model by taking dimensions on existing physical part.*

Automotive control arm acts as a linkage between spring and unspring mass of vehicle. Lower arm is subjected to various loading during braking, cornering, and vertical loads. Existing lower control arm modeled in CAD package (CATIA). Discretization done using Ansys. Static Structural analysis and optimization achieved using Ansys solver. Post processing plots of strain from results used to mount strain gauge at identified location. Experimental loading applied using UTM machine and strain gauge indicator used to measure strains. Comparative analysis done between experimental and FEA results. Conclusion given with study of this paper.

Keywords- A-Arm, Static Strutral Analysis, Optimization

I. INTRODUCTION

The Wishbone lower arm is a type of independent suspension used in motor vehicles. The general function of control arms is to absorb the shock loads comes from irregularities on the road also to keep the wheels of a vehicle from uncontrollably swerving when the road conditions are not smooth. The control arm suspension is normally of upper and lower arms. The upper and lower control arms have different design and structures based on the model and purpose of the vehicle and load on vehicle or application. By many accounts, the lower control arm is the better shock absorber than the upper arm because of its position and load bearing capacities.

In the automotive industry, the riding comfort and handling Qualities of an automobile are majorly depends on the suspension system, in which the suspended portion of the vehicle is attached to the wheels by elastic members in order to cushion the impact of road irregularities. The specific nature of attaching linkages and spring elements varies widely among automobile models. In these systems the unsprung weight of motor vehicle is decreased, More soft springs are permissible, and front-wheel vibrations will be minimized. The control arm (or wishbone or A arm) is nearly flat and roughly triangular member, that pivots in two places. The broad end of triangle is attached to the frame and pivots are attached on the bushing. The narrow end attaches to the steering knuckle and pivots attached on the ball joint. During running condition lower control arm subjected to loads due to variation in gross weight and impact loads due to fluctuation of road surface and additional forces such as braking and cornering. Because of this irregularity on the road, the chances of bending and hence failing of lower control arm at ball joint will be high which is undesirable, hence it is important to carry out static and modal analysis of lower or upper control arm. Due to more competition in automotive world, major automotive OEM’s have been forced to reduce fuel consumption and hence cost of vehicle while assuring the safety. Hence, minimizing weight is now important & major task in automotive industry without affecting reliability and durability.

Topography optimization is an advanced form of shape optimization in which a design region for a given parts are defined and a pattern of shape variable-based reinforcements within that region is generated. The approach in topography optimization is based on topology optimization, except that shape optimization is used rather than density variables. The design region is sub-divided into a large number of separate variables whose influence on the structure is calculated and optimized over a series of iterations. A FEA model of the structure is built. Loads and boundary conditions are applied. The design-space finite- elements where beads can exist are selected as the optimization domain. Bead parameters are set up (height, width, draw angle, draw direction).This paper deals with calculation of various forces acting on lower control arm of independent suspension system and modeling of lower control arm. Also this paper describes structural and modal analysis using different materials. Topology optimization also carried out for lower control arm in order achieve weight reduction.

II. LITERATURE REVIEW

Sagar Darge et al. This paper provides the information about Finite Element Analysis of the Lower or Upper Control arm suspension of double wishbone suspension which involve stress optimization under static loadings. The suspension system is one of the most important components of vehicle, which has impact on the safety, performance, noise level and style of it. However, these static load conditions could not represent all the severe situations of automobile parts which subjected to complex loads varying with time, especially for lower control arm of front suspension. Lower Control arm of suspension system modeled using CATIA V5. In first step of analysis area is to calculate maximum stress area. These analyses were carried using ANSYS. In order to reduce stresses and to improve structural strength Topography optimization approach is carried out in ANSYS in which a design region for a given part is defined and a pattern of shape variable-based reinforcements within that region is generated to increase Stiffness [1].

Young-Chul Park et al. this paper, recently developed automotive components are getting lighter providing a higher fuel efficiency and performance. In this research, the shape of upper control arm was determined by applying the optimization technology. This study considers the static strength in the optimization process. In this study, the kriging interpolation method is adopted to obtain the minimum weight satisfying the static strength constraint. Optimum design of static strength is obtained by the in-house program. MSC fatigue is used for assessment of the durability life, which is one of the most important criteria in automotive industry. In addition, the real experiments on 1/4 car is conducted to validate the FEM analysis. At last, the correlation of each case about durability life is obtained [2].

Vinayak Kulkarni et al. This paper provides calculation for the forces acting on lower wishbone arm while motor vehicle is subjected to critical loading conditions i.e road irregularities. (Braking, Cornering and descending though slope).Mostly all passenger cars and light trucks use independent suspension system because of inherent advantages over rigid suspension systems. Double wishbone system is named as Short Long Arm system consists of upper and lower wishbone arms. While actual running conditions forces like braking, cornering and vertical loads are taken by lower arm of suspension system, hence probability of failure of lower arm under these forces is more. Lower Control arm suspension modeled using Pro-Engineer/ Catia. Von Mises stress –strain calculated in order to find out maximum induced stress and strain, while modal analysis is done for finding out natural frequencies and mode shapes of component. These analyses were carried using Altair Hyper works and solver used is Radios. From the analyzed results, design parameters were compared for two different materials and best on was taken out. From result obtained it was found that current design is safe and is somewhat overdesign.[3].

Kaustubh V. Kulkarni et al. in this paper deals with static analysis of the upper arm suspension of double wishbone suspension. The vehicle suspension system is always responsible for driving safety and comfort. The suspension unit carries the whole vehicle body and transmits all forces between body and road. Mostly Structure optimization techniques in static load conditions have been used in automotive industry for light weight and for performance improvement of modern new cars. However, these static loading conditions could not represent all the severe situations of various automobile parts which subjected to complex loads those varying with time, especially for lower control arm of front suspension of automobile. This paper shows the study of practical example for static analysis and optimization of upper control arm of Chevrolet. In this optimization of upper control arm 6.29% weight reduction is achieved [4].

Lihui Zhao et al. structure optimization techniques under static load conditions have been widely used in automotive industry for lightweight and performance improvement of modern cars. However, these static load conditions could not represent all the severe situations of automobile parts which subjected to complex loads varying with time, especially for lower control arm of front suspension. This study describes about dynamic optimization of lower control arm performed with combination of traditional static load optimization techniques and multi-body dynamics by Equivalent Static Load (ESL). And the better draw-bead distribution of the stamped double wishbone lower control arm was attained. Comparing the MBD analysis results of the new design derived from dynamic optimization and original structure, results show that the strength and stiffness was increased significantly while the mass was almost unchanged [7].

III. PROBLEM STATEMENT

The suspension control Arm (lower), this research work shall attempt CAE analysis over the existing model of the passenger car for identifying the problem areas while deliberating on design alternatives to suffice the function. This would help the design team to redesign the part for safe operation while aiming for adequate strength for addressing the function.

IV. OBJECTIVES

1. Static structural Analysis of Automotive A-arm.
2. Optimization of Automotive A-arm.
3. Stress plots.
4. Deformation plots.

V. METHODOLOGY

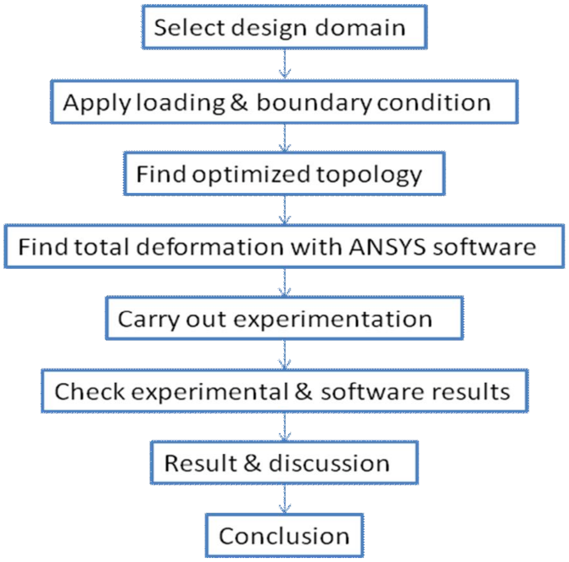


Fig.No.1 Flowchart for the Methodology

VI. STATIC ANALYSIS

1. Material Properties:

1.	Steel	
2.	Modulus of Elasticity	: 200GPa
3.	Poisson’s ratio	: 0.30
4.	Density	: 7.85e-6 kg/mm^3
5.	Yield Strength	: 520 MPa
6.	Mass of the body	: 2.6042kg

2. Finite Element Analysis:

Design of existing suspension control Arm is done by using CAD package CATIA V5 as per following;

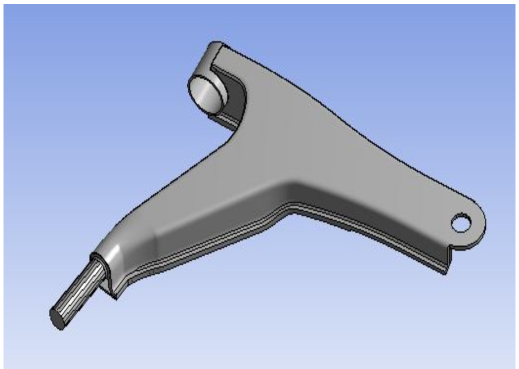


Fig.No.2 Original Model

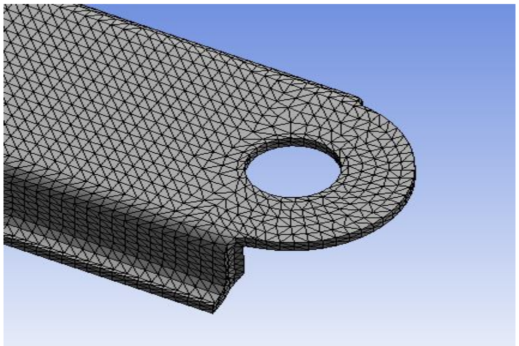


Fig.No.3Solid Mesh

Elements Details:

1. Element Type: Tetrahedron
2. Element Order: second Order
3. Mesh Method: Solid
4. Node Population count: 154821
5. Element Population count: 80483

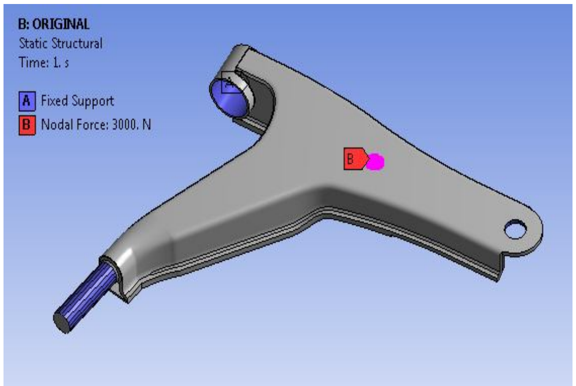


Fig.No.4 Boundary Conditions Original Model

1. Total weight of Indica = 1000kg=10000N (Approx)
2. Around 60 per load acts on front axle= 6000N
3. Load Acting on one ARM = 6000/2=3000N

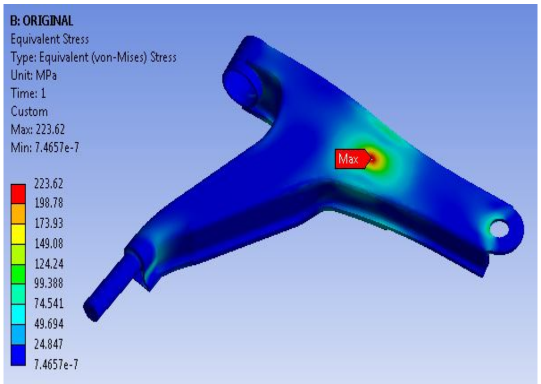


Fig.No.5 Von-Mises Stress Original Model

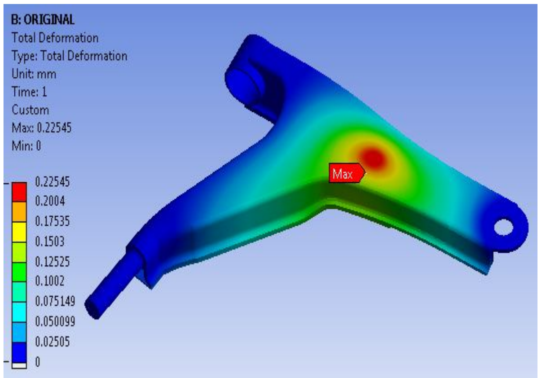


Fig.No.6 Deformation Original Model

VII. OPTIMIZATION

Optimization is a process of determining the best design from a given design and material by applying loads and boundary conditions.

Mass of the body = 2.433kg

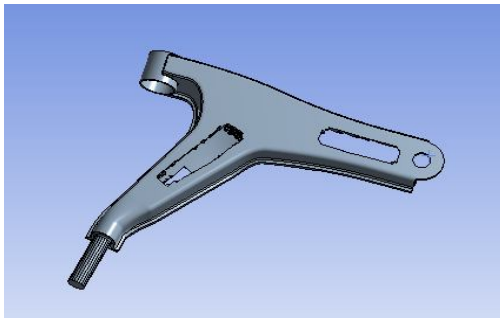


Fig.No.7 Optimized Model

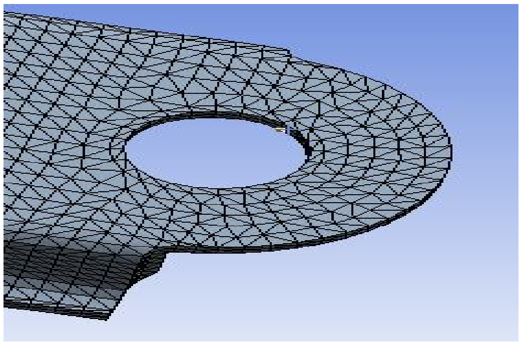


Fig.No.8 Solid Mesh

Elements Details:

- Element Type: Tetrahedron
- Element Order: Second Order
- Mesh Method: Solid
- Node Population count: 1288
- Element Population count: 696

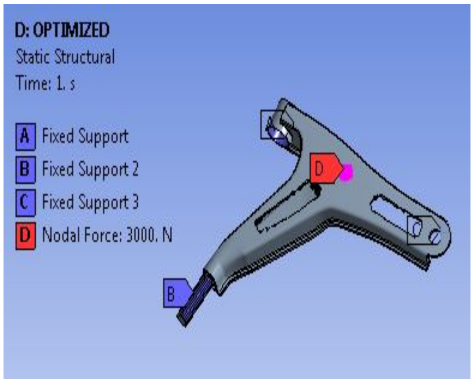


Fig.No.9 Boundary Conditions Optimized Model

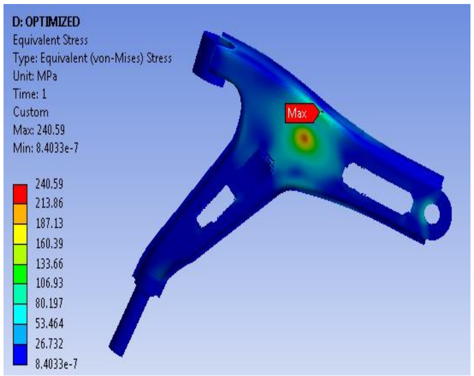


Fig.No.10 Von-Mises Stress Optimized Model

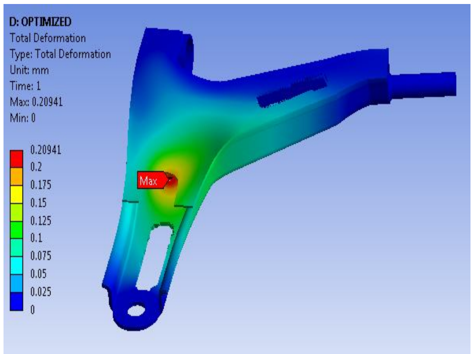


Fig.No.11 Deformation Optimized Model

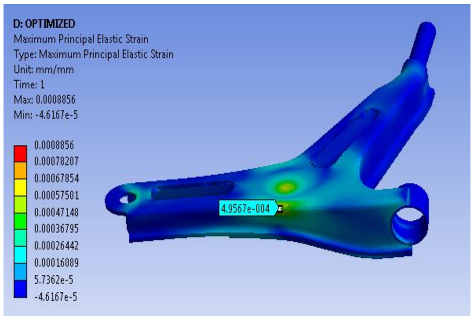
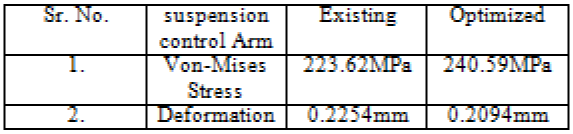


Fig.No.12 Maximum Principal Strain Optimized Model

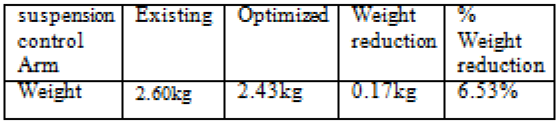
VIII. RESULTS & DISCUSSIONS

After, Experimental testing is carried for static loading condition on suspension control Arm following Results obtained:



Sr. No.	suspension control Arm	Existing	Optimized
1.	Von-Mises Stress	223.62MPa	240.59MPa
2.	Deformation	0.2254mm	0.2094mm

Weight Reduction of suspension control Arm:



suspension control Arm	Existing	Optimized	Weight reduction	% Weight reduction
Weight	2.60kg	2.43kg	0.17kg	6.53%

IX. CONCLUSION

The suspension control Arm had the potential for optimization and weight reduction. Experimental loading applied using UTM machine and experimental analysis done. The optimized suspension control Arm is 6.53% lighter than the existing suspension control Arm. Deformation of control arm reduced to 0.2094mm.Both design produced stresses are within the yield limit 520 MPa of the material.

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