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DESIGN ANALYSIS OF LOWER CONTROL ARM OF MAC PHERSON SUSPENSION SYSTEM

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ABSTRACT:

The most important component in vehicle is suspension system, which directly affects the safety, performance and noise level. Suspension arm is one of the most important components in the suspension system. It is fitted in various types of the suspensions like Macpherson, wishbone or double wishbone suspensions. The lower control arm is a wishbone-shaped metal strut that attaches the wheel to the vehicle's frame. In order to determine the deformation and stress distribution in the current design, the finite element analysis is carried out. The baseline model of the lower control arm is created by using solid modeling software viz. CATIA. ANSYS Workbench is used for Finite Element Analysis This study deals with Finite Element Analysis of the Lower control arm of Mac-pherson suspension system.

KEYWORDS: LCA, FEA, Mac-pherson.

INTRODUCTION:

Vehicle suspension system fulfils various purposes. It provides a vertical obedient element between un-sprung and sprung mass in order to maintain contact between ground and wheel, by reducing the sprung mass motion. It maintain proper attitude of the vehicle during various operating conditions like braking, cornering, accelerating. It also road holding and steering characteristics. Overall performance of suspension system is limits on maximum suspension travel, transmissibility of forces, road holding, minimum weight and cost[1]. There are three different types of suspensions namely: Dependent (Rigid Axle), independent and semi-independent suspensions. In the independent suspension system, there are no linkages between two hubs of same axle and it allows each wheel to move vertically without affecting the opposite wheel. This system has inherent advantages over dependent system such as more space for engine, better roll resistance, lesser un-sprung weight and better resistance to steering vibration. Dependent suspension or rigid axles provide a solid connection between two wheels of the same axle. Therefore motion of one wheel is transferred to the other wheel while travelling along surface irregularities .Semi rigid suspensions system shows intermediate characteristics between the other two categories [2].

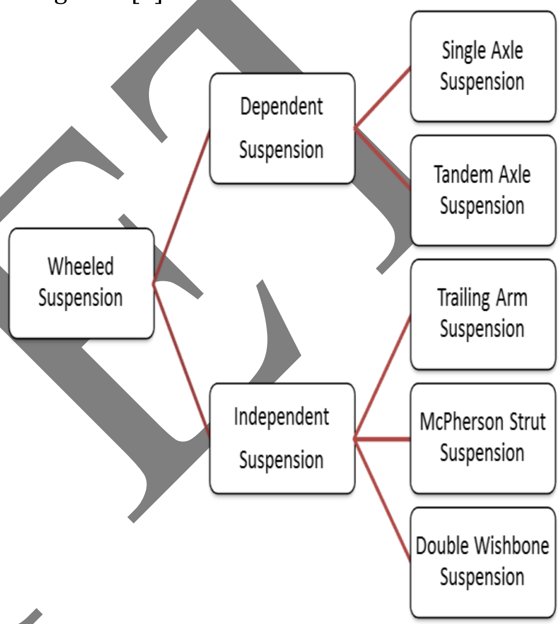

Fig. 1 Classification of Wheeled Suspension

A. PROBLEM DEFINITION:

The design of a suspension system is very important. When the vehicle passes on road, it exhibits the impact loads. We experience the sudden motion along with the vehicle; it is very uncomforted to the passengers. The design of a suspension system comes into the picture under this scenario's.

There is absence of balance rod in recent modified Indian light commercial vehicle, which is part of suspension system. Balance rod act as a supportive member for lower control arm of suspension system. Due to absence of balance rod maximum stresses are transferred to lower control arm.

B. OBJECTIVE:

In order to solve above mentioned problem, main aim of the project is summarize below:

- To carry out strength evaluation of lower control arm of one of the Indian light commercial vehicle.
- To carry out reverse engineering on existing model and prepare 3D model using CATIA software.

- To carry out static structural analysis of existing model using FEA based software ANSYS workbench.
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C. METHODOLOGY:

II. THEOROTICAL ANALYSIS:

A. DIMENSION OF LOWER CONTROL ARM:

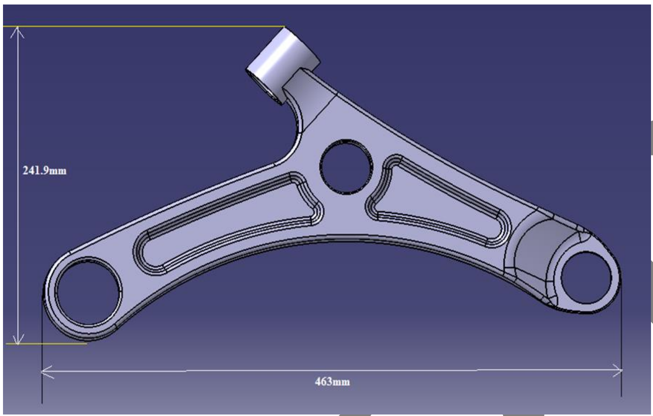

Fig. 2. Dimension of Lower Control Arm

Dimension of Lower Control Arm is as follows:

Length:463mm

Height:241.9mm

B. MATERIAL PROPERTIES:

Lower control arms have to withstand high load carrying capacity. This material is in existing component. The Material should have higher the yield point, elasticity, buckling strength, etc. The material is AISI 1040, which is having all these characters.

TABLE I. MATERIAL PROPERTIES

Sr.No.	Description	Values
1	Modulus of Elasticity, MPa	2e5
2	Poisson's Ratio	0.3
3	Yield Strength, MPa	800
4	Density, Kg/m3	7850

C. STATIC LOAD CALCULATION OF LOWER CONTROL ARM:

Gross Weight of Wagon R =1350 Kg
(considering passengers and accessories weight)
Total Weight in Newton = 1350*9.81

W =13243.5 N

It is assumed that 52% of weight taken by front axle, due to mounting of engine on front side and remaining 48% weight taken by rear axle. Therefore,

Weight on Front axle = 0.52*13243.5 N

F1= 6886.62 N

Weight on Rear axle = 0.48*13243.5 N

F2 = 6356.88 N

Reaction at each front wheel

Rw= Weight on Front axle/2

Rw = 6886.62/2

Rw =3443.31 N

This load is constituted by spring, axle and lower control arm.

While stub axle of the wheel takes 50% of the total load acting on each wheel.

Therefore, force acting on the front axle of wheel is given by,

F= 1721.6 N

Following line diagram is a representation of the spring, axle, and lower arm.

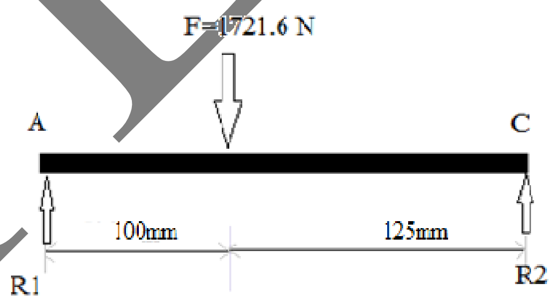

Fig.3. Line diagram for force distribution

Where,

R1=Reaction for spring in Newton.

R2=Reaction for lower arm in Newton.

F = Force acting on stub axle in Newton

Therefore, from equilibrium condition, taking moment at A is equal to zero.

∑MA = 0

F2 *100- R2*225 = 0……………………….(1)

1721.6 *100 =R2*225

R2 = (1721.6*100)/225

R2 =765.15 N

This is vertical load acting on the lower control arm.

Now, R1 + R2 =F2

R1 = F2 – F1…………………………..(2)

R1 =1721.6-765.15

R1 =956.45 N

This reaction is acting vertically upward at spring.

Therefore, the Reaction R2 = 765.15 N

Approximately taken as R2 ≈ 765 N, which is acting in vertically downward direction on lower control arm.

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III. MODELING OF LOWER CONTROL ARM:

CAD software like CATIA is higher end software which is feature based solid modelling systems. CATIA V5R22 is used for modelling of Lower Control.

A. "2DMODELING" OF EXISTING LOWER CONTROL ARM:

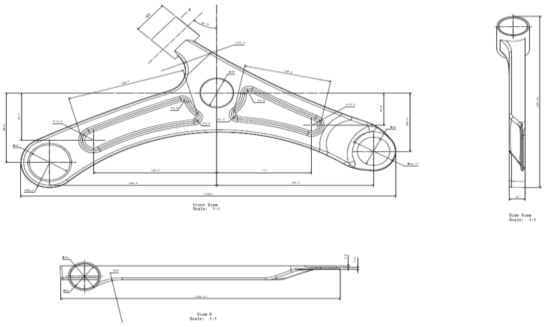

Fig.4. '2D' Views of Lower Control Arm

B. "3DMODELING" OF EXISTING LOWER CONTROL ARM:

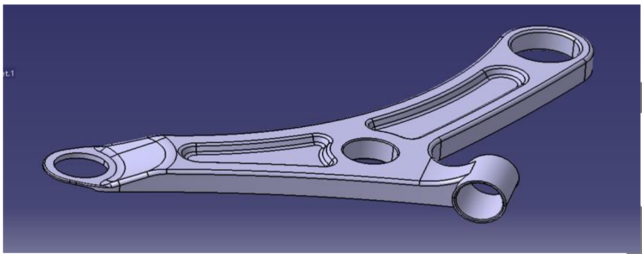

Fig. 5.Top View 3D of Lower Control Arm

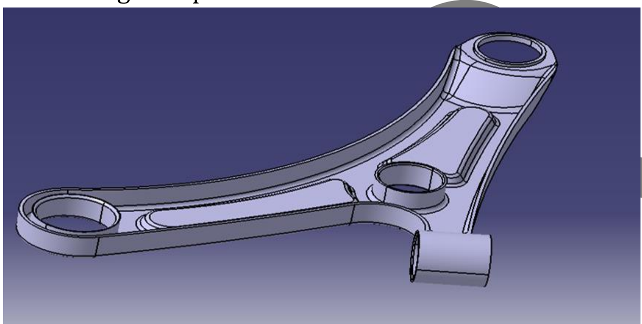

Fig. 6. Back View 3D of Lower Control Arm

IV. FINITE ELEMENT ANALYSIS:

ANSYS software is used to mesh the solid model. Cad model which is in IGES format is imported to ANSYS.

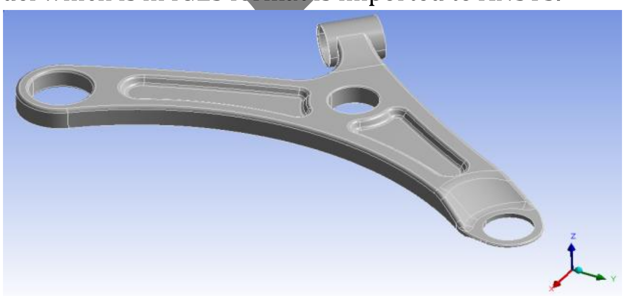

Fig. 7. Baseline Lower Control Arm for FEA

A. MESHING OF BASELINE GEOMETRY:

The conventional model which was developed in CATIA software has to be meshed for analysis. For this ANSYS workbench software is used. It is a high-performance finite element pre-processor that provides a highly interactive and visual environment to analyze product design performance. With the broadest set of direct interfaces to commercial CAD and CAE systems. The solid tetrahedron elements are used to generate the meshing of the control Arm.

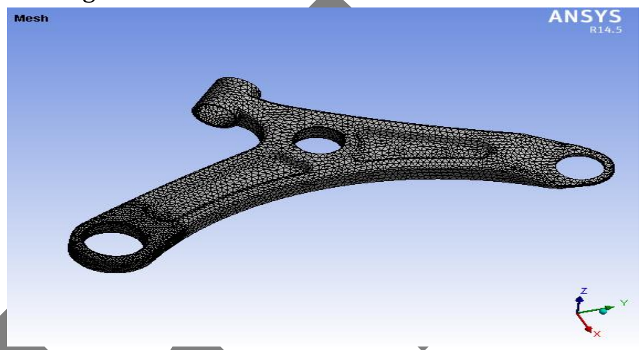

Fig. 8. Meshing of Lower Control Arm

TABLE II. DETAILS OF MESHING

Sr. No.	Description	Values
1	Number of Nodes	53002
2	Number of Elements	26694
3	Element Size	Max. 5 mm, Min. 3 mm

B. DESIGN PARAMETERS:

In case of vehicle in actual running conditions forces acting on it are of dynamic in nature and changes as per driving conditions. Various longitudinal forces are acting due to braking and acceleration while lateral forces acting due to cornering of vehicle. In order to make preliminary analysis steady state operating conditions are assumed. The assumptions made are smooth road conditions, steady state cornering and constant grade.

C. BOUNDARY CONDITIONS OF BASELINE GEOMETRY:

Wheel is mounted on stub axle which is connected to steering knuckle. This steering knuckle has three arms let say upper arm, lateral arm and lower arm. Upper arm is connected vertical helical coil spring strut , lateral arm is connected to tie rod of steering mechanism and lower arm is connected to wishbone or lower control arm by a ball joint. Other two end are connected to chassis frame, out of which one is fixed and other end turn about a pivot.

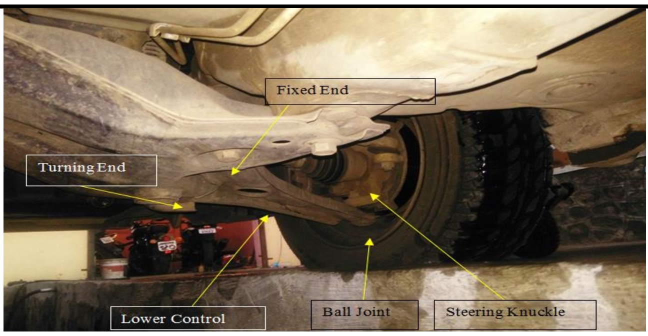

Fig. 9. Connection of Lower Control Arm

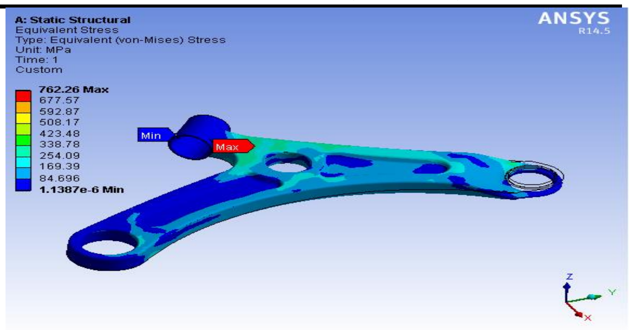

Fig.12(a). Equivalent Stress Plot

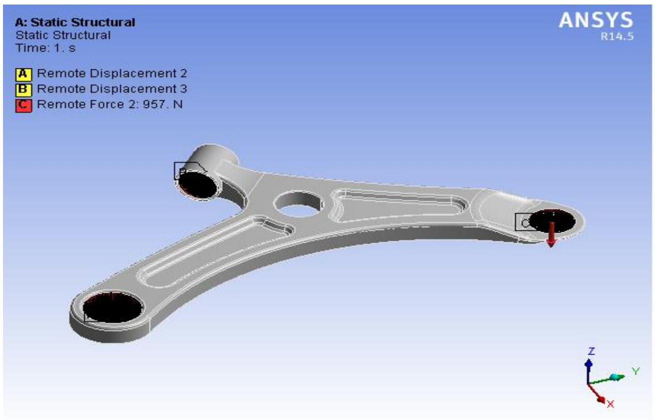

Fig. 10. Boundary conditions of lower control arm.

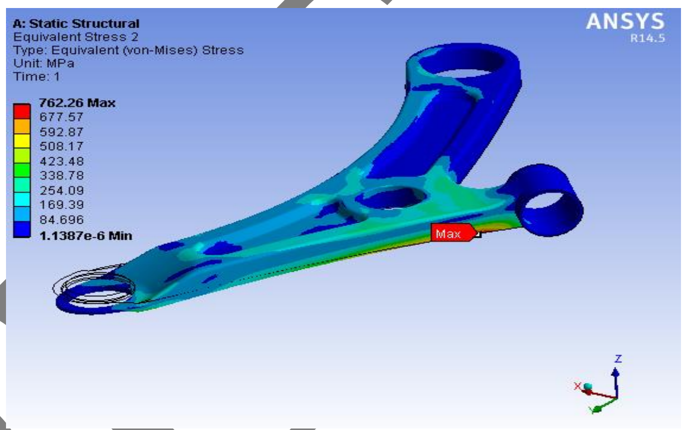

Fig.12 (b). Equivalent Stress Plot

D. ANALYSIS RESULT OF BASELINE MODEL:

After Finite Element analysis on ANSYS workbench 14.5 following results have been find out. The displacement contour plots are shown in the below figure. The maximum displacement shown by the control arm is 10.74 mm. As per distortion energy theory, the maximum equivalent stress observed in the lower arm model 677 MPa. The yield strength of the material is 800 MPa. According to results, the von-Mises stress 677 MPa is greater than yield strength of the material. The factor of safety of the baseline lower Arm is 1.18.

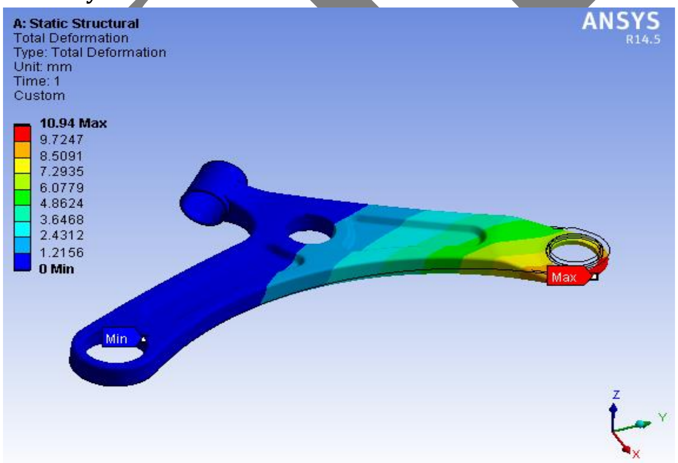

Fig. 11.Maximum deformation Plot

The following figure shows contour plot of the von-Mises stress.

V. RESULT AND DISCUSSION:

It is observed from the results that maximum stresses are developed at sharp corners and hole of the lower control arm.

TABLE III. RESULTS

Sr. No.	Method	Description	Baseline Design
1	FEA Method	Deflection, mm	10.74
2		Von-Mises stress, MPa	677
3		Mass, Kg	1.20

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