Material Optimization of Upper Control ARM for Double Wishbone Suspension System

Aadesh.R.Shinde[1], Suyog.S.Wangi[2], Umesh.S.Kaur[3]

[1]*Student, Department of Mechanical Engineering, R.M.D Sinhgad School of Engineering, Pune, Maharashtra, India*
[2]*Student, Department of Mechanical Engineering, R.M.D Sinhgad School of Engineering, Pune, Maharashtra, India*
[3]*Professor, Department of Mechanical Engineering, R.M.D Sinhgad School of Engineering, Pune, Maharashtra,India*

***

Abstract – *Suspension system plays an essential role in automobile and is always responsible for driving comfort and safety. Suspension system not only absorbs the tremendous vibrations but also transmits various forces between road and vehicle body. The double wishbone suspension system provides balanced stability under various conditions like cornering, braking, loading and unloading. A Double Wishbone Suspension system consists of upper control arm, lower control arm, strut, knuckle, etc in which upper control arm is crucial part of suspension system. An upper control arm joins steering knuckle to vehicle frame. In an automobile industry optimization is focused all aspects for improvement in performance of modern SUV's. This project consists of A-type control arm and contributes towards material optimization and analysis of upper control arm for double wishbone suspension system. Upper control arm is designed using CATIA V5 and FEA on ANSYS is used for post processing. Required forces like Lateral, Longitudinal and Vertical forces acting on arm are calculated. Static analysis is performed comparing various materials and best suitable material with desired results will be manufactured. Following model should validate the applied boundary conditions. Upper control arm fabricated will be made from hollow pipe with preferred material for weight consideration.*

***Key Words*:** double wishbone, suspension, upper control arm, material, CATIA V5, ANSYS

1. INTRODUCTION

The double wishbone suspension system is called as an independent suspension system usually using two parallel wishbone type arms locating one end knuckle and another end to vehicle or chassis frame. The middle portion of the wishbone consists of a shock absorber or strut which isolates the bump vibrations inducing in a vehicle. The arms can be casted, forged or made from sheet metal. Also, in some applications, the arms are considered as hollow pipe portion joining the frame and knuckle. The hollow pipe lower or upper arms can be fabricated using various metals as per vehicle force consideration and sustainability. In double wishbone system, more amount of load is applied on ball joint during vibrations and maximum load is transferred from upper to lower which results in twisting of lower arm and upper control arm due to impact load. To minimize the weight and develop a new model for upper control arm of an automobile it is useful to study and focus on stress, deformation by optimizing it materially with suitable and sustainable material with modified structure.

1.1 Suspension System

The suspension system consists of shocks, springs, multiple linkages which connects vehicle frame and permits relative motion by absorbing tremendous vibrations. The suspension system maintains the relation between tire and road and keeps them contacted as much as possible. The maximum travel, camber and castor improvement, roll centre height, anti dive and anti squat are major aspects related to suspension system which are important for any vehicle. Suspension types are dependent, independent and semi-dependent type. The main perspective of suspension system is to provide better steering handling, vehicle stability and maintain comfort to passengers by absorbing and damping system.

Fig -1: Suspension System

1.2 Control Arm

In double wishbone system, the control arms can be categorized into lateral and longitudinal arms. Arms connecting to the chassis and pointing outward are lateral, while wheel up – down control motion arms are longitudinal arms. Upper control arm carries the braking and driving torque. Vertical, Lateral and Longitudinal forces are applied on this arm. The control arms can be classified as A type, U type and H type arms. The upper control arm is probably shorter to induce negative camber as the suspension jounces (rises) and usually called as "Short Long Arms" or "SLA". The typical control arms are also called as tension or compression arms.

Fig -2: Upper Control Arm

2. Problem Definition

2.1 Problem Statement

The need of market today is to produce light weight automobile parts. The main aim is to reduce weight of suspension system by materially optimizing the upper control arm for double wishbone suspension system to reduce weight and increase strength. This will ultimately result in reduction of part cost.

2.2 Project Objectives

- To reduce the overall weight by 10-12%.
- Upper control arm optimization by material comparison.
- To reduce the cost of the component and improve performance of vehicle.

3. Force Calculation

A. Static Condition

The gravitational pull of earth which is W=mg is acting through centre of gravity. It acts on contact patches between tyres and roads. To assume the boundary conditions acting on a vehicle, the upper control arm from SUV is taken into consideration. The SUV is from TATA Motors and model is Safari.
Let R_1 be the front axle weight and R_2 be the rear axle weight. The weight must be divided into front axle weight and rear axle weight. 52% of total weight is taken by front axle and 48% of total weight is taken by rear axle.
Total weight of vehicle = 2650 kg = 25987.6 N
Therefore, Front axle weight =1378 kg = 13513.5 N
Reaction at one wheel = 1378/2 = 689 kg = 6756.8 N
Therefore, Rear axle weight = 1272 kg = 12474.05 N

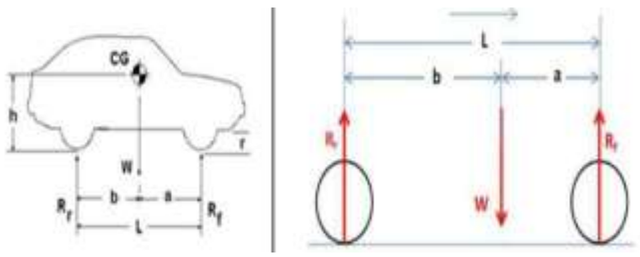

Fig -3: Static Forces

B. Static and Dynamic Loads

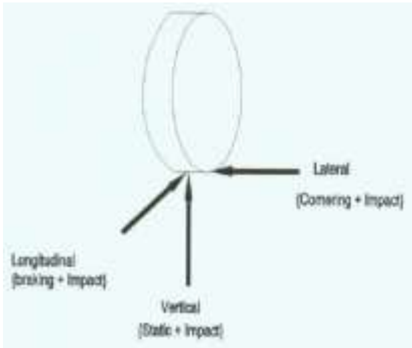

Fig -4: Wheel Loads and Directions

Table –1: Input Safari Parameters

Description	Symbol	Value
Total Weight of vehicle	W = F	25987.6 KN
Weight on Front axle	F_1	13513.5 N
Weight on Rear axle	F_2	12474.05 N
Tyre rod coefficient	μ	1.5
Wheel Base	L	3040 mm
Average acceleration	Ā	2.5 m/s^2
Centre of gravity height	hcg	1950 mm
Vehicle mass	M	1200 kg

For unknown bcg value, consider a simply supported beam in which F = 22.56 KN which acts at a distance X from point A.

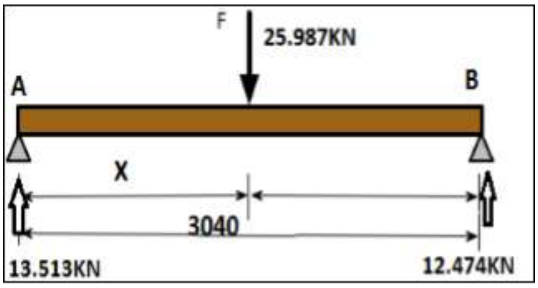

Fig -4: Force on Axle simply supported beam

Taking Moment at pt. A :
ΣmA = 25.987 *X – 12.47 * 3040 = 0
X = 145 9.23mm
Bcg = 3040 – X = 1580.77 mm

a) Front Axle Breaking Force (FB)

FB = 0.5 μ(Static+Dynamic)
= 0.5 μ((W*bcg/l)+(m*a*hcg/l))
= 0.5 μW((bcg/l)+(a*hcg/gl))
FB = 11.57 KN

b) Vertical Force (FV)

FV = 3/2 [Static+ dynamic load]
FV = 3/2 [W *bcg/l + m* ā *hcg/l]
= 3/2 W [bcg *g + ā *hcg / gl]
= 23.155 KN

c) Lateral Force (FL)

FL = W [Static+ dynamic load]

FL = W [bcg* g + ā* hcg / gl]

= 17.75 KN

4. Proposed Upper Control Arm Model

The new, modified model is created in CATIA V5 with hollow pipe structure. This model consists of circular structure of metallic element rather than existing sheet metal design. The new component is designed as per existing safari upper control arm dimensions and adopted via reverse engineering method. After creation, preferred materials are added for weight consideration on CATIA software. CATIA part is then imported in ANSYS.

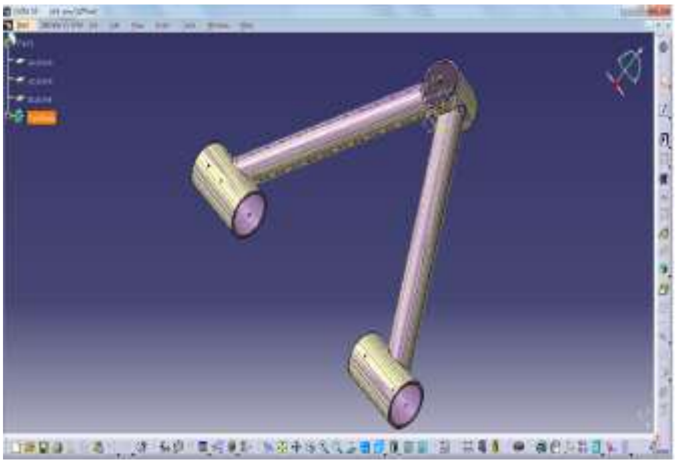

Fig -5: Modified UCA

5. Material Optimization of Proposed UCA

Analysis based on material plays a vital role as to find its stress, deformation and allowable stress is considered for safety purpose. Comparing various materials, best suited material is selected for upper control arm showing better properties to withstand the impact load. ANSYS is done for each and every material and material with suitable properties is selected. Material properties can be compared and best can be selected from following table shown below:

Table -2: Material Properties

Materials used for UCA/ Properties	Aluminium 7075	AISI 4140	AISI 4130	Stainless Steel 321
Young's Modulus (E)	71.7 GPa	200 GPa	210 GPa	189 GPa
Poissons's Ratio (v)	0.28	0.33	0.30	0.265
Density (ρ)	2.81 g/cm³	7.85 g/cm³	7.85 g/cm³	8 g/cm³
Yield Strength (σ yield)	500 MPa	415 MPa	435 MPa	410 MPa
Ultimate Tensile Strength (σ uts)	570 MPa	655 MPa	680 MPa	620 MPa

After this, various mechanical and physical properties of elements are added in ANSYS. The model is meshed after adding properties. The meshing of upper control arm is done using tetrahedral element mesh. Forces and Boundary conditions are applied to the component. Lateral, Longitudinal and Vertical forces are applied to ball joint according to dynamic directions. Finally von – misses stress and total deformation for various materials is analysed and sustainable material is selected within limit of factor of safety. Analysis of upper control arm is a not one time method and is carried out through iteration method which takes more amount of time. Results of various metallic materials are compared and safest, high strength material is chosen for component fabrication.

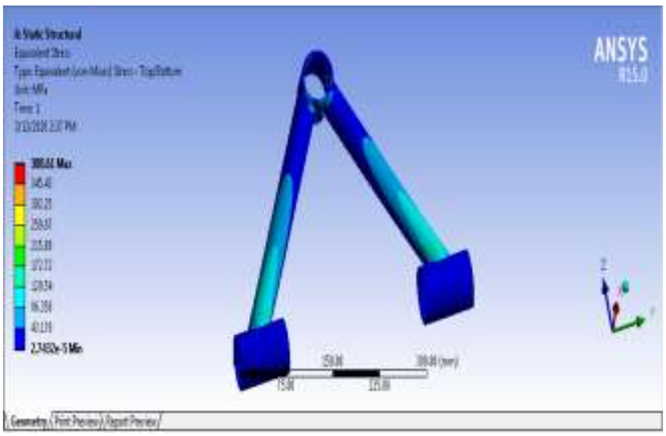

Fig -6: Total Stress

From the result table it can be concluded that AISI 4130 is having best result compared to other materials. Deformation is not more than 1 mm. Rest all materials have less yield stress than steel 4130. The Factor of Safety is up to 1.5 for which the Upper Control Arm is within sustainable and safe limit. Also, Steel 4130 is having 12 % less weight and 11.5 % less stresses. It also has higher allowable strength than structural steel.

6. CONCLUSION

The material optimization through FEA using ANSYS can be used for overall effective performance and weight reduction for an upper control with improvement in strength. Selected final optimized UCA shows deformation and stress within safe limit and 4130 steel is best option or suitable material for existing UCA. Optimization showing lesser weight than existing UCA is an essential part of the project.

REFERENCES

[1] Mayur.S.Aware, W.S.Rathod, "Investigation Optimise Parameter Of Upper Control Arm For Mining Breaker ", International Journal of Research in Engineering and Technology, Volume:07 Issue:06, Jun-2018, pp-101-112.

[2] Bhushan S. Chakor, Y.B.Choudhary, "Analysis And Optimization Of Upper Control Arm of Suspension System", International Journal of Research in Engineering and Technology, Volume:05 Issue:01, Sept-2017, pp-2808-2814.

[3] Nikhil R. Dhivare, Dr. Kishore P. Kolhe, "Vibration Analysis And Optimization Of Upper Control Arm Of Light Motor Vehicle Suspension System", International Journal for Innovation Research in Science and Technology, Volume:03 Issue:02, July-2016, pp-346-367.

[4] S. Mahaboob Khan, T.V.V.S.N.Murti, "Modelling And Structural Optimization Of Upper Control Arm Using FEA", International Journal of Research, Volume:02 Issue:11, November-2015, pp-789-793.

[5] Shantanu Garud, Pritam Nagare, Rohit Kusalkar, Vijaysingh Gadhave, Ajinkya Sawant, " Design And Optimization Of Double Wishbone Suspension System for ATVs", International Journal of Research in Engineering and Technology, Volume:04 Issue:12, Dec-2017, pp-847-851.

[6] Nikita Gawai, Deepak Yadav, Shewta Chavan, Apoorva lele, Shreyash Dalvi, "Design, Modelling and Analysis of Double Wishbone Suspension System", International Research and Development of India, Volume:04 Issue:1, 2016.

[7] Mr. Balasaheb Gadade, Dr. R. G. Todkar, "Design, Analysis of A-type Front Lower Suspension Arm in Commercial Vehicle", International Journal of Research in Engineering and Technology, Volume:02 Issue:07, Oct-2015, pp-759-766.

[8] Savan Thacker, Antriksh Bhatt, "Research Paper on Design and Analysis Double Wishbone Suspension System using Finite Element Analysis", International Journal of Advance Research in Engineering, Science and Technology , Volume:02 Issue:7, July-2015, pp-19-22.

[9] Jong-kyu Kim, Seung Ku Kim, Hwan-jung Son, Kwon-Hee Lee, Young-Chul Park, " The 9th WSEAS International Conference on Applied Computer And Applied Computational Science", Volume:04 Issue:14, Dec-2010, pp-811-817.

[10] V.V.Jagirdar, M.S.Dadar, V.P.Sulakhe, "Wishbone Structure For Front Independent Suspension of a Military Truck", Defence Science Journal, Volume 60, No. 2, March-2010, pp-178-183.