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DESIGN OPTIMIZATION AND ANALYSIS OF LOWER CONTROL ARM

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Abstract: The lower control arm is a unique type of independent suspension used in automobile vehicles. During the actual working condition, the maximum load is transferred from upper arm to the A arm which creates possibility of failure in the arm. Hence it is essential to focus on the stress analysis of A suspension arm to improve and modify the existing design. A suspension arm is an important part used in a suspension system of a car suspension arm performance a major role in managing the motion of the wheel during bump, turning, and breaking. This paper proposed the design optimization and model analysis of steel cast for the front A suspension arm was investigated. CATIA software was utilized to design the suspension arm. ANSYS 19 software was also used for analyzing the structural strength and optimize the parts weight. The target of the new design was a 20% weight reduction from the existing part fabricated using steel material. Testing and validation of new design using FEA analysis. Modal analysis carried out to find out natural frequencies of A suspension arm and validation are done with the help of Static Structural Analysis using ANSYS software, Impact Hammer Test & UTM.

I. INTRODUCTION

Electric-mobility, CO2 emission limits, gasoline, global warming and energy prices are some of the factors driving lightweight automotive design. Lightweight design requires suitable, economic manufacturing technologies in addition to the use of lightweight materials. Hence, it

is a challenge to automotive manufacturer to produce the lightweight vehicle without compromising their performance. Weight reduction enables the manufacturer to develop the same vehicle performance with a smaller engine, and such a smaller engine enables the use of

a smaller transmission and fuel tank. With these ripple effects, it is estimated that 10% of vehicle weight reduction results in 8–10% of fuel economy improvement. Lightweight approach could be achieved in various ways. Criteria of lightweight path could be changingto a new material which is superior in the sense of mechanical properties without compromising the state of the current component’s properties. The use of lightweight materials can help to reduce vehicle weight and improve fuel consumption. The pressure for weight reduction has driven a gradual decrease in the amount of steel and cast iron used in vehicles and the corresponding increase in the number of alternative materials especially aluminium. The suspension system caries the vehicle body and transmit all forces between the body and the road without transmitting to the driver and passengers. The suspension system of a car is used to support its weight during varying road conditions. The suspension system is made of several parts and components. These includethe front and rear.In the automotive industry, handling qualities of car is an important issue. These qualities are greatly affected by the suspension system. The suspended portion of the vehicle is attached to the wheels. To cushion the impact of road irregularities suspension arm is connected. Suspension arm is the main component in automotive suspension system. It carries all the different loads created due to irregular roads. There are various types of suspensions like wishbone or double wishbone suspensions. There are lots of research works which consist of suspension system, different types of suspension system, upper and lower control arm. The lower control arm is subjected to many loads due to variation in gross weight and impacts due to fluctuation of road surface and additional forces. Beside all this technological advancement, there can be excessive stress development in lower control arm. During running condition, the arm is subjected to many loads. The chance of bending and failing of lower control arm takes places because the complex nature of loads. These loads are due to fluctuation of road surface and additional forces like braking and cornering. Due to this chance of bending and hence failing of lower control arm takes place. Hence it is necessary to carry out static. In this paper static of lower control arm is performed. With help of finite element approach it becomes easy to carry out this analysis within short period of time. With rapid development in technology there are different optimization techniques for weight reduction used in industries. Some of the techniques consist of topology optimization, shape optimization, material substitution etc. Weight optimization of components for vehicles is becoming more important. The application of topology optimization is done for weight reduction. This method is efficiently applied to weight reduction on lower control arm. Weight optimization of lower control arm is done, and results are checked for same.

The most important component in vehicle is a suspension system, which directly affects the safety, performance, and noise level. The unspring mass is the mass of the suspension components which is directly connected to them, rather than supported by the suspension. High unspring weight exacerbates issues like wheel control, ride quality and noise. Unspring weight includes the mass of components such as the wheel axles, wheel bearings, wheel hubs, springs, shock absorbers, and Lower Control Arm. The lower control arm is a wishbone-shaped metal strut that attaches the wheel to the vehicle's frame. Different optimization techniques under various load conditions have been widely used in automobile sector for lightweight and functioning enhancement.

The lower control arm gets more attention by much research like study dynamic analyses of the motor vehicle suspension system using the point-joint coordinate's formulation. The mechanical system is replaced by an equivalent constrained system of particles and then the laws of particle dynamics are used to derive the equations of motion. Modelling and simulation are indispensable when dealing with complex engineering systems. It makes it possible to do an essential assessment before systems are developed. It can provide support in all stages of a project from conceptual design, through commissioning and operation. The most effective was to improve product quality and reliability is to integrate them in the design and manufacturing process.

II. PROBLEM STATEMENT

Chassis parts are a critical part of a vehicle, leaving no room for error in the design and quality the present process relates to a computer-aided structure analysis and design graphic display device and method, and more particularly, to a computer-aided structure analysis of lower control arm and which is analysed and designed, thereby meet the customer requirements of LCA. This project is to optimize the lower control arm by doing Static Structural Analysis by ANSYS software and Impact Hammer Test by suggesting suitable material, and reducing sheet metal thickness, to reduce the batch production cost and to increase the strength ofLCA.

III. OBJECTIVES

1. To prepare CAD design using CATIA V5 software.
2. Static structural Analysis of existing Automotive lower control arm.
3. Optimization of New Automotive Lower Control Arm.
4. To perform static structural analysis of the suspension arm using ANSYS Software, Impact Hammer Test and FEA Analysis.
5. Experimental testing of optimized design. Validation of experimental and numerical result of both LCA.

IV. METHODOLOGY

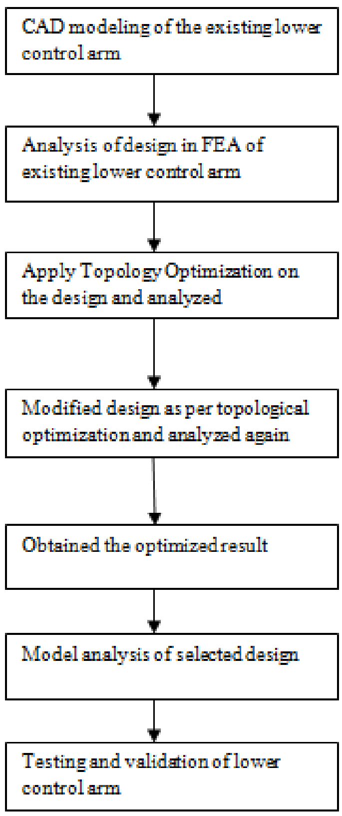

Fig.No.1 Flowchart for the Methodology

4.1 DESIGN

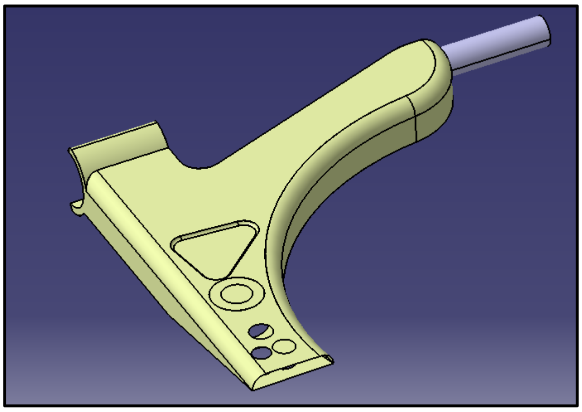

Fig. 2 CATIA and drafting of modified LCA

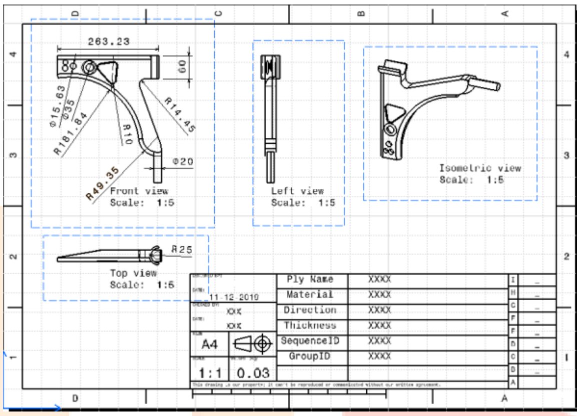

Fig. 3: Drafting of existing lower control arm

4.2 FEA (FINITE ELEMENT ANALYSIS)

The finite element method (FEM), is a numerical method for solving problems of engineering and mathematical physics. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain. To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. It is generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it.

- Consider weight of car – 1000 kg in which load on each arm is calculated by dividing by 4 in which 250 kg is applied at each end. So, converting into weight is 250 x 9.81 = 2500 N (g = 10 m/s^2).
- In boundary condition two fixed surface are mounted on same frame of chassis as indicated in blue colour are applied with force of 2500 N applied at ends as per existing case.
- Maximum deformation obtained after application of load is 1.5 mm

4.3MODIFIED LOWER CONTROL ARM

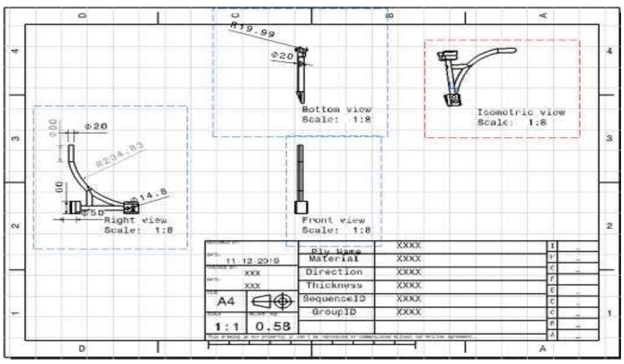

Fig. 4CATIA and drafting of modified LCA

4.4 EXPERIMENTAL TESTING USING FEA

Fig. 5 Maximum elastic strain

4.4.1 Testing on UTM

4.4.2 Testing on Impact Hammer Test

4.4.3Testing on FFT analyzer

Natural frequency (Hz)MODESHAPE	FEA	Experimental	PercentageerrorinExperimental and theoreticalanalysis(%)
1	297.45	292.96	1.51
2	704.17	703.12	0.15
3	871.46	859.37	1.39
4	1175.9	1171.87	0.34
5	1462.8	1445.30	1.20
AveragepercentageerrorinExperimentalandtheoretical analysis			**0.92**

V. COMPARISION OF EXISTING VS OPTIMIZED LCA

5.1 Existing LCA

- Weight – **2.6042 Kg**
- Raw material cost for LCA mild steel is calculated by using volume of material used, density & material cost per Kg which is **Rs 131/-**
- Hourly cost required is **Rs 6050/-**& cycle time for **1** piece is **17 Secs**.
- Machining cost for existing LCA is Rs **36**& Tooling cost is **Rs 240/-**
- Total production cost is **Rs 407** by considering raw materials, tooling & machining cost.
- Maximum deformation and stress are **1.5** mm and **684 Mpa.**
- Strain measurement of **1952** microns is observed by numerical and experimental testing.

5.2 Optimized LCA

- Weight – **2.0833 Kg**
- Raw material cost of optimized LCA is calculated by using volume of material used, density & material cost per Kg which is reducing to **Rs 110/-**
- Also machining cost for the same is **Rs 21**, because the cycle time has reduced upto **10** Secs.
- Hence the total production cost of LCA by considering raw materials, tooling & machining cost is **Rs 371/-**
- Hence after optimization there is cost saving of **8.8%**& weight reduction of **20%**
- Maximum deformation and stress **2.08** mm and **476 MPa** which are less than existing design.
- Strain measurement of **1970** microns is observed by numerical and experimental testing.
- So, it is beneficial to use modified design after existing design.

VI. CONCLUSION

1. Static analysis of lower control arm with existing and modified design have been performed to evaluate deformation and equivalent stress.
2. In existing design maximum deformation and stress are 1.5 mm and 684 MPa and modified design evaluated as 2.08 mm and 476 MPa which are less than existing design. So, it is beneficial to use modified design after existing design.
3. Modal analysis is performed to determine mode shape pattern with respective natural frequency.
4. Strain measurement of 1952 microns and 1970 microns by numerical and experimental testing respectively.
5. Hence it is confirmed that the modified design of the lower control arm is safe and has added advantage that it is reduced in the weight by 8% than the existing lower are system used in the market.

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