Analysis and Optimization of FLCA Using Finite Element Based Topology Optimization Technique

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ABSTRACT

Front lower control arm (FLCA) is a component used in a suspension system of a light vehicle. It plays a whittle role in handling the motion of the wheel during the bump, turning, and braking. The scope here in this present work is to optimize the front lower control arm with respect to weight with four different materials. Present work, the new design concept of FLCA is presented. CATIA software has been used for the modeling, design concept of the FLCA. After that, ANSYS software is used to analyze the structural strength and optimized the part using topology optimization technique to achieve accurate dimensions with less mass. To verify the initial work, existing model has been taken from literature as the base and verified it. The work also determines the natural frequency before and after optimization. The target of the new design is 20% reduction of the overall mass of the front FLCA which manufactured by suitable material. Finally, the work has been observed that using topology optimization technique reduce mass of the FLCA without owing its responses.

Keywords: *FLCA, ANSYS, Finite Element Analysis, Topology Optimization.*

1. Introduction

The particular idea of connecting linkages and spring components changes broadly among car models. The best rides are made potentially by free suspension frameworks, which allow the wheels to move autonomously of each other. In these frameworks the unsprang weight of the vehicle is diminished, gentler springs are allowable, and front-wheel vibration issues are limited. Spring components are utilized for vehicle suspension, expanding request of their capacity to store versatile vitality per unit of weight. Suspension arm is one of the principle segments in the suspension frameworks. It can be seen in different sorts of the suspensions like wishbone or twofold wishbone suspensions. The vast majority of the circumstances it is called as A-type control arm. It joins the wheel center to the vehicle outline taking into account a full scope of movement while keeping up appropriate suspension arrangement.

Figure 1. Front lower control arm (FLCA)

Topology optimization (TO) is a mathematical method that optimizes material layout within a given design space, for a given set of loads, boundary conditions and constraints with the goal of maximizing the performance of the system.

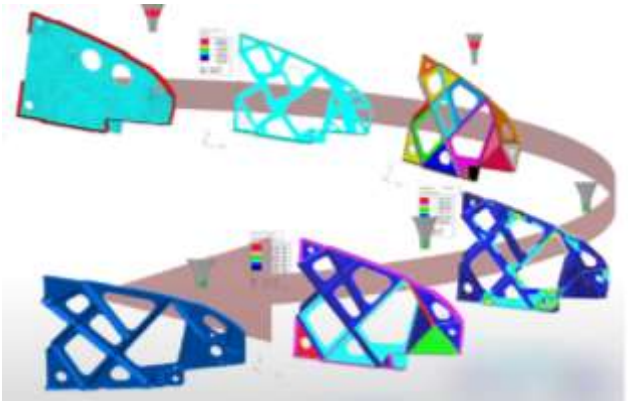


Figure 2. Topology optimization [3]

2. Methodology

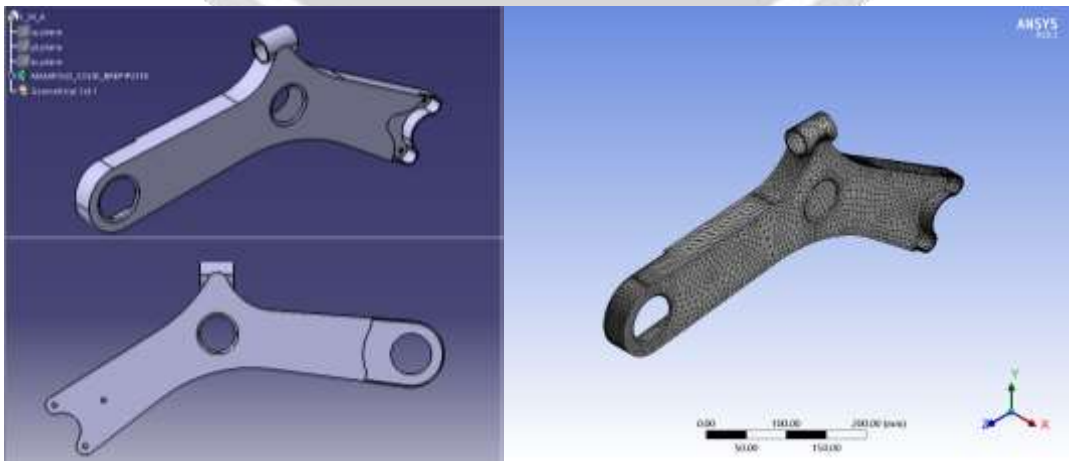
Front Lower Control Arm (FLCA) is as integral component of a frame and suspension system and it is classified under functional component on the basis on its application. So, the optimal designed are required for better performance of existing design. Now in this work is to perform the structure analysis and of an LCA and further optimized the design or shape of the same. CATIA software is employed in this present work to design the concept of the LCA and after that, ANSYS software is considered to analyze the structural strength and optimized the weight with respect shape of the part.

2.1 Analysis of Lower Control Arm

Analysis of the lower control arm is required to find out the maximum stress (weaker section), shear stress and deflection in the arm. Maximum von-mises stress, shear stress and deflection in the LSA can be found by using software. The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM).

Table 1 Material Properties used in FLCA

Properties	Materials			
	EN 24	Fe 410	Fe 590	C70 Steel
Density (kg/m^3)	7850	7685	7850	7695
Young's Modulus (GPa)	210	210	200	211.5
Poisson's Ratio	0.3	0.285	0.3	0.3



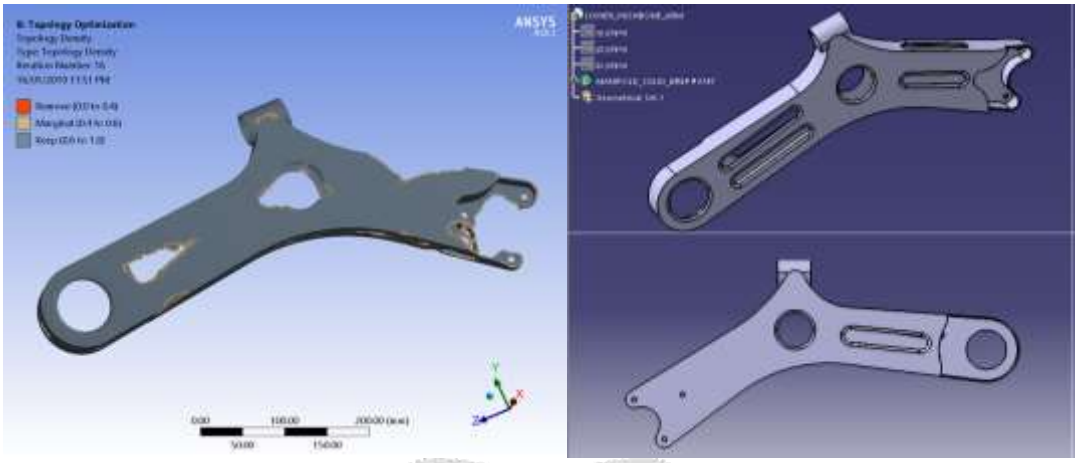


Figure 3. Base model, meshed view, topology optimization and modified Model of FLCA

3. Results & Discussions

The main objective of this present work is to model and to perform structural as well as vibration analysis of a lower control arm used in the front suspension system. After performed analysis the topology optimization has been done and the optimum results are obtained. Before topology optimization the existing model has been verified by available Ref. [12].

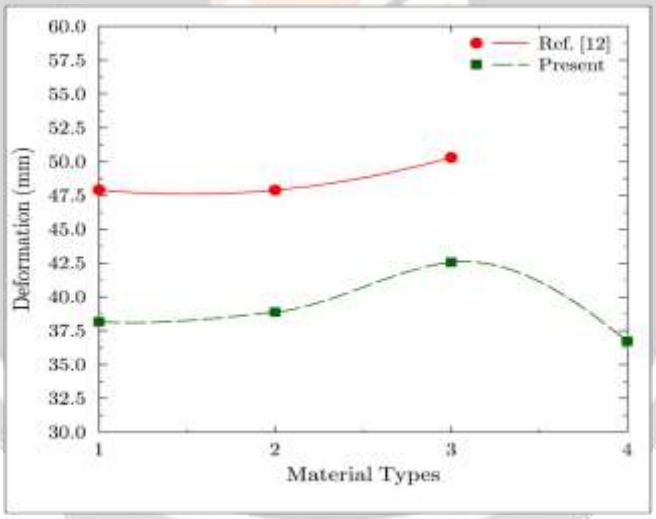


Figure 4. Graphical of comparison of total deformation to different materials

Figure 4 – 8, representing that the total deformation, von-mises stress, shear stress, vibration and mass of the different material types which obtained from analysis respectively. The graph clearly shows that the for total deformation existing model are high as compared to present and the 4th type of model is given the minimum total deformation, total deformation, von-mises stress, shear stress, vibration and mass, which is good for application.

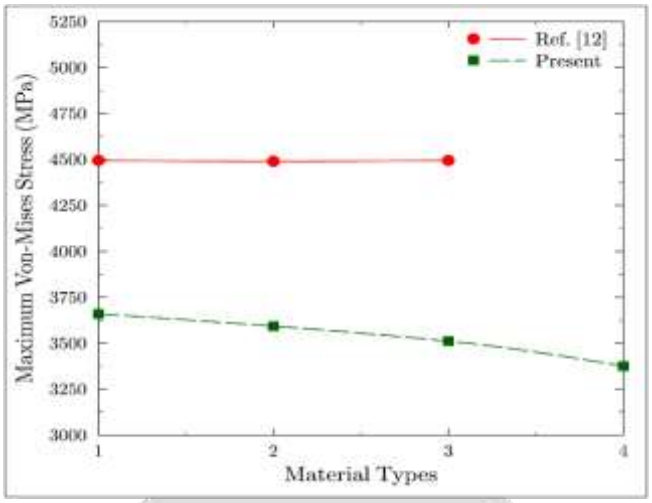


Figure 5. Graphical comparison of Von-Mises stress to material types

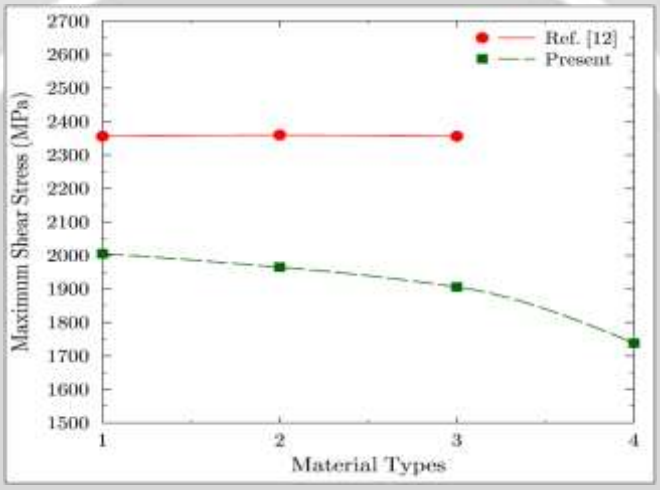


Figure 6. Graphical comparison of maximum shear stress to material types

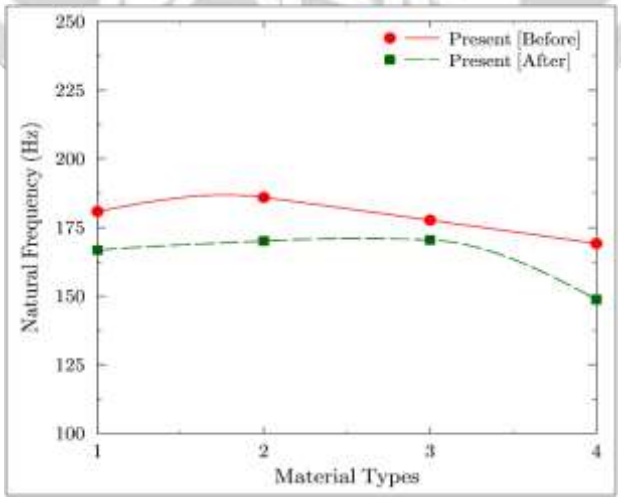


Figure 7. Graphical comparison of natural frequency to different materials

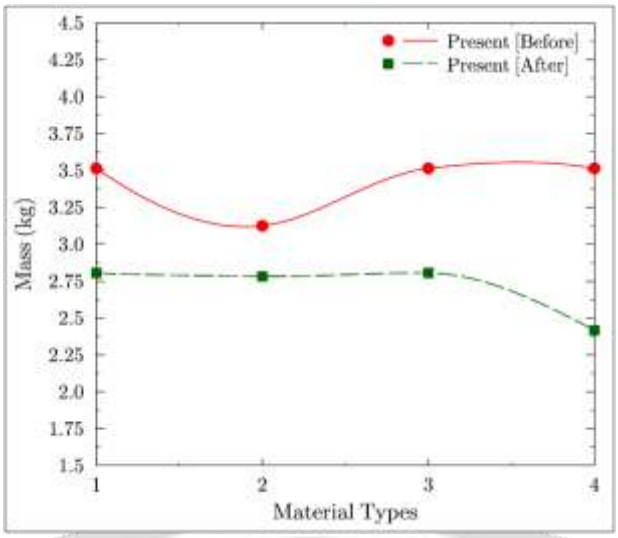


Figure 8. Graphical comparison mass before and after optimization different materials

4. Conclusion

- The front lower control arm is one of the widely used in independent suspension system. This arm is transferred maximum load from upper arm to lower arm during motion. So, the main aim of the work is to improve the performance of the arm.
- The main goal of the present work is to research and investigate to design new light weight of FLCA using topological optimization and introduced the effective material (C70 steel) to be used in FLCA.
- It has been observed in the present work that using optimized or modified design reduces total deformation in design, von-mises stress and shear stress as well as minimum natural frequency.
- Using topology optimization technique, the reduction of mass can be achieved about 31% compared to current or existing design concept of FLCA.
- From the present investigation it is concluded that the unique and robust design gives better performance compared to current commercial FLCA.
- Also, from this present work has been concluded form using topology optimization technique, the mass of the design is reducing with minor effecting the output response.
- The topology optimization tool given the good agreement between tradition designing as well as non-traditional optimization techniques.
- This technique has been significance in designing from concept to final model within less time.

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