Design and Analysis of Front Lower Control Arm by Using Topology Optimization

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ABSTRACT

The lower control arm is a type of independent suspension used in vehicles. During the actual working condition, the maximum load is transferred from upper arm to the lower arm which creates possibility of failure in the arm. Hence it is essential to focus on the stress analysis of lower control arm to improve and modify the existing design. The present work will contribute in this problem by using finite element analysis approach. So, the main objective of this work is to model and to perform structural analysis of a lower control arm. The lower control arm is modeled in solid works software as per given specification in literature. To analyze the lower control arm, ANSYS FEA software is used. The standard modeled analyze and optimized using ANSYS topology optimization tool which is give most useful result in present. Using the topology shape optimization technique, the total deformation, von mises stress, maximum shear stress and mass will be reduced as compared to previous work. In this work also taken three types of materials for lower control arm i.e. EN24, Fe410 and Fe590. By reducing mass of the object and by suggesting the suitable material and design the production cost of lower control arm is reduced. This leads to cost saving and improved material quality of the product.

Keywords: *Front Lower Control Arm, ANSYS, Topology Optimization.*

1. Introduction

The A-arm (called a Volvo control arm) attaches the suspension to the chassis of the vehicle. There may be as many as three or four control arms when coil springs are used in both the front and rear suspension systems. Upper control arms carry driving and braking torque, while the lower control arms pivot, providing up-and-down movement for wheels. A-arms can be used in different configurations and numbers. Two A-arms per wheel makes up a suspension system called a double wishbone suspension, or an independent suspension.

The control arms of a vehicle connect a vehicle's steering rack to the wheels of the car, and they hold the wheels to the car's frame. Control arms allow the wheels to move and manage the motion of the wheels by pivoting. They assist in the wheels to response to varying road conditions by allowing the wheels to lift and descend as the wheels encounter bumps, dips, or other obstructions in the road. In addition to allowing for movement, control arms also assist the wheels in maintaining straight lines in relation to the road.

Figure 1. A-arm suspension lower arm

1.1 Topology Optimization

A topology optimization in a finite element context modifies the connectivity of finite elements with respect to a pre-defined objective with associated constraints. An example is that the maximum stiffness of a structure is sought for a given amount of material. Furthermore, it is convenient to assume linear isotropic material behaviour with small deformation theory. By performing a shape optimization on a structure, its shape in terms of thickness and radius is varied where non-linear and fatigue material behaviour can be taken into account. As the need to cut lead times in the product development process as well as the need to reduce weight of automotive vehicles increases, it becomes more natural to include topology and shape optimization in earlyphases of the component development process.

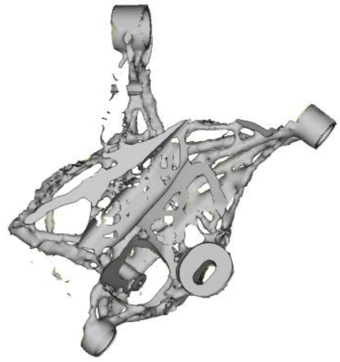


Figure 2. Topology optimization [3]

2. Problem Statement

Control arms can bend or break when driving over large potholes, bumps while brushing can also wear out. Sometimes due to combination of forces like pitching, rolling, acceleration breakdown occurs due to large stress. To optimize the upper control arm of suspension system with modeling and transient structural analysis of arm based on material. Modal analysis is done in addition. Further optimize arm compared by good literature which is mention in reference.

3. Methodology

The important role of the suspension system is to compensate forces that occur as a result of the accelerations of the car. Also, it makes the vehicle more comfortable and safe. So, the optimal designed are required for better performance of existing design. Now in this chapter is discussed about method applying in the work for optimized design.In this work the solid work software and ANSYS 18.1 has been selected for modeling and analysis optimization for the object.

Methodology outline is:

- CAD modeling of the existing lower control arm
- Analysis of design in FEA of existing lower wishbonecontrol arm
- Apply Topology Optimization on the designand analyzed
- Modified design as per topological optimization and analyzed again
- Obtained the optimized result.

Table 1. Material Properties [9]

Properties	**Materials**		
	EN 24	**Fe 410**	**Fe 590**
Density (kg/mm^3)	7850	7685	7850
Young's Modulus (MPa)	2.1E+05	2.1E+05	2E+05
Poisson's Ratio	0.3	0.285	0.3
Yield Tensile Strength (MPa)	680	290	490
Yield Compressive Strength (MPa)	680	290	490
Ultimate Tensile Strength (MPa)	850	510	590
Ultimate Compressive Strength (MPa)	0	0	0

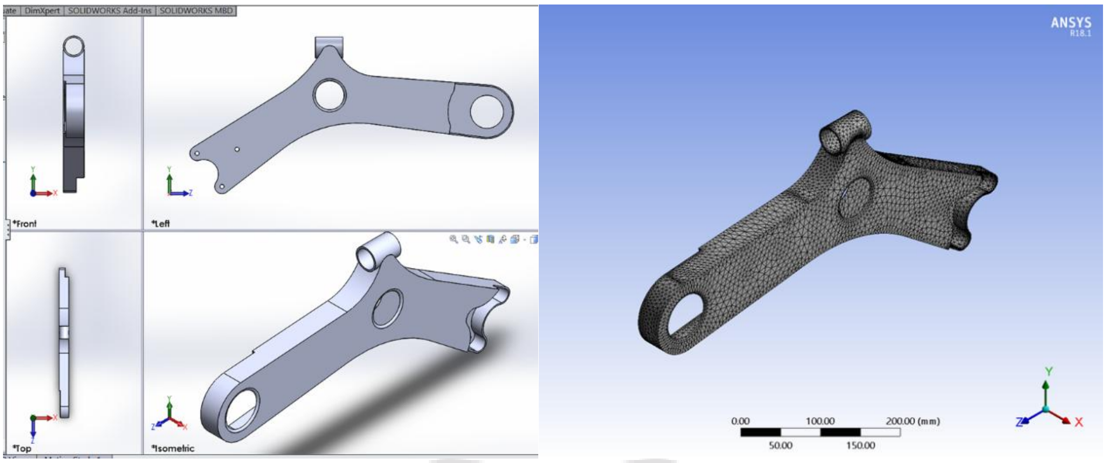
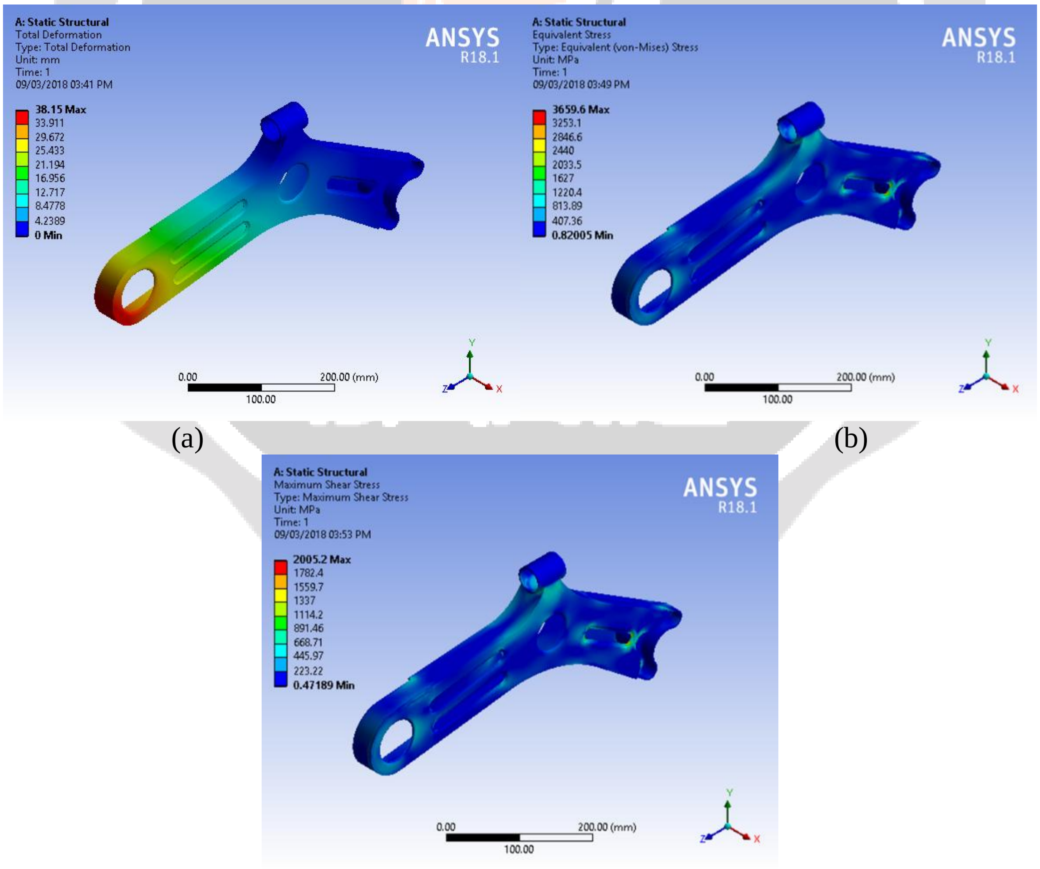


Figure 3. 3D model (left) and meshed views of front lower suspension arm (right)

4. Results & Discussions

After done the topology optimization the results are obtained. This all results are discussed in this chapter with comparing and improvement with a good literature [9].



(a) (b)

(c)

Figure 4. Result of deformation, von-mises and maximum shear stress obtained from ANSYS

Above Figure 4 shows for EN24 material, for other material same procedure can be done.

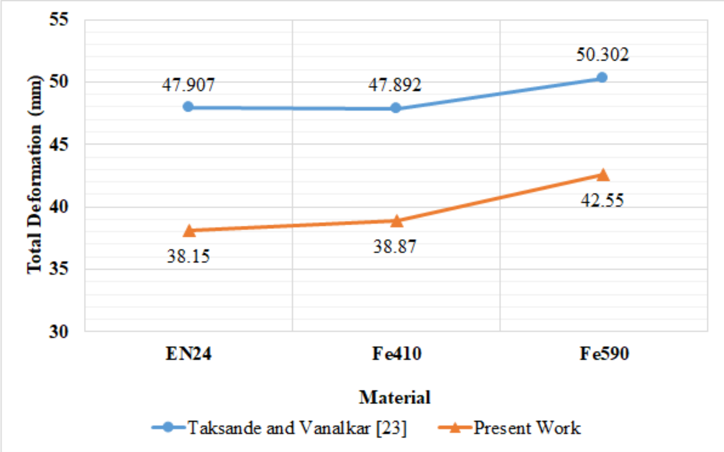


Figure 5. Graph of comparison of total deformation to different materials

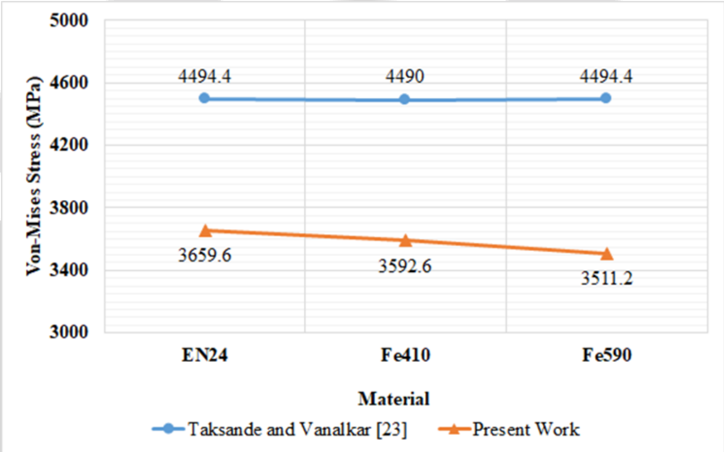


Figure 6. Graph of comparison of Von-Mises stress to different materials

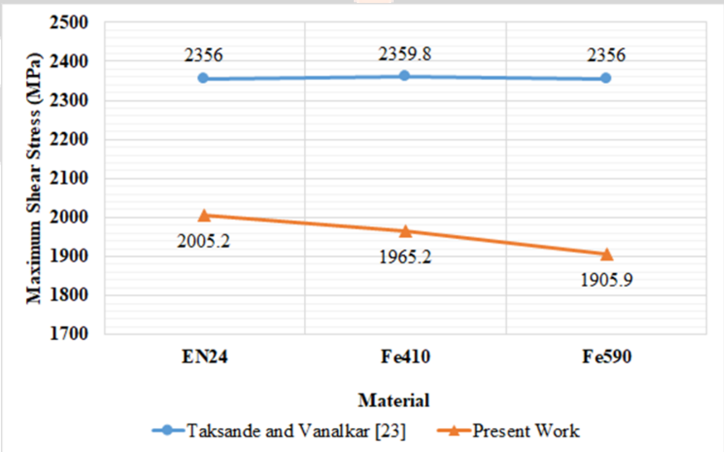


Figure 7. Graph of comparison of maximum shear stress to different materials

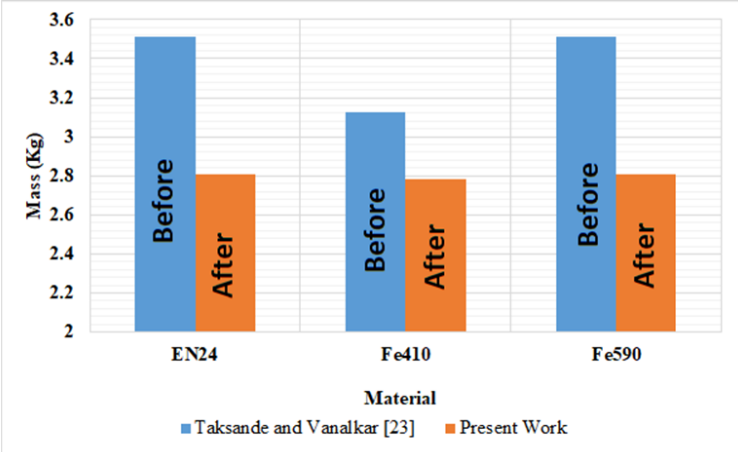


Figure 8. Graph of mass before and after optimization different materials

5. Conclusion

Due to the various functions of control arm is very important parts in suspension. As vehicle passes through bump, speed breaker etc. differing types of forces functioning on the wheels that are transmits to regulate arm via attachments i.e. ball joint assembly etc. to the wheel. These force and force values are mention within the load case.In this work the existing component design and its function for identifying potential areas for modification and secure geometry and import the same over the pre-processor for Discretization. Upon finding results for structural and topology analysis, use the inputs for pursuing mass optimization Recommend the new design for implementation.Also, the 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 and non-traditional optimization techniques.

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