Experimental and FEA of Optimized Existing Lower Control ARM

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ABSTRACT- *The lower control arm is an interesting kind of autonomous suspension utilized in car vehicles. During the genuine working condition, the most extreme load is moved from upper arm to the lower control arm which makes plausibility of failure in the arm. Henceforth it is fundamental to concentrate on the stress investigation of lower control arm to improve and alter the current design. A lower control arm is a significant part utilized in a suspension arrangement of a vehicle. So, this arm execution a significant job in dealing with the movement of the wheel during knock, turning, and breaking. In present research design of lower control arm in CATIA software. ANSYS 19 software was also used for analyze the structural strength and optimize the parts weight along with modal analysis to determine natural frequency with mode shape and validate the results with FFT technique. 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 FFT technique.*

Keywords- LCA, FEA, Modal Analysis, Impact Hammer Test, FFT Analyzer

1. INTRODUCTION

Electric-versatility, CO_2 emanation limits, fuel, an Earth-wide temperature boost and vitality costs are a portion of the variables driving lightweight car structure. Lightweight structure requires appropriate, financial assembling advances notwithstanding the utilization of lightweight materials. Thus, it is a test to car producer to create the lightweight vehicle without trading off their presentation. Weight decrease empowers the producer to build up a similar vehicle execution with a littler motor, and such a littler motor empowers the utilization of a littler transmission and fuel tank. With these expanding influences, it is assessed that 10% of vehicle weight decrease brings about 8–10% of mileage improvement. The suspension framework caries the vehicle body and transmit all powers between the body and the street without transmitting to the driver and travellers. The suspension arrangement of a vehicle is utilized to help its weight during fluctuating street conditions. The suspension framework is made of a few sections and parts. These incorporate the front and back. In the car business, dealing with characteristics of vehicle is a significant issue. These characteristics are extraordinarily influenced by the suspension framework. The suspended segment of the vehicle is connected to the wheels. To pad the effect of street inconsistencies suspension arm is associated. Suspension arm is the principle part in car suspension framework. It conveys all the various burdens made because of sporadic streets. There are different kinds of suspensions like wishbone or twofold wishbone suspensions. There are loads of research works which comprise of suspension framework, various kinds of suspension framework, upper and lower control arm. The lower control arm is exposed to numerous heaps because of variety in net weight and effects because of vacillation of street surface and extra powers. The unsprung mass is the mass of the suspension segments which is legitimately associated with them, instead of upheld by the suspension. High unsprung weight intensifies issues like wheel control, ride quality and commotion. Unsprung weight incorporates the mass of parts, for example, the wheel axles, wheel course, wheel centre points, springs, safeguards, and Lower Control Arm. The lower control arm gets more consideration by numerous explores like examination dynamic investigations of the engine vehicle suspension framework utilizing the point-joint facilitates detailing.

2. LITERATURE REVIEW

M.H.A. Rahmanet al. [1] In this paper it presents the plan streamlining of aluminum cast for the front lower control arm. The outcomes demonstrated a critical decrease of the general load as high as 25% with an exhaustion life cycle roughly 396,000 cycles. Subsequently, the new plan of front lower arm has satisfied the models of weakness life cycle and is appropriate to be utilized in a C-fragment traveler vehicle. The primary goal of this exploration is to structure another lightweight of front lower control arm for the C-Segment vehicle utilizing topology improvement process. In light of the last plan idea of FLCA, the absolute weight is 2.55 kg, which is about 25% of weight decrease contrasted and the present metal stepping FLCA weight 3.40 kg and still keeps up the auxiliary quality exhibition and weakness strength execution. The new structure of this aluminum cast lower control arm has novel plan contrasted and the present business plan. The I-bar cross segment gives higher solidness and second to the parts to support the higher twisting second.

Kale A Ret al. [2] In this paper it presents to investigate and upgrade the lower arm utilizing limited component examination. Lower control arm is exposed to different loads. Because of this sort of loading, there are odds of twisting of control arm. Thus, failure of lower control arm happens. Weight decrease of vehicle segment is one of the principle concerns. Topology enhancement of lower arm is performed for weight decrease. After topology improvement static examination of upgraded lower control arm is done. Results acquired from examination where concentrated to check whether the structure is inside the yield quality. The motivation behind car suspension framework is traveler solace and vehicle control. The consequence of stress produced by static examination of existing lower control arm is 223.62MPa. After improvement the outcome acquired for pressure investigation of advanced lower control arm is 240.59MPa. In this manner, the structure is sheltered by yield quality standards. The heaviness of existing lower control arm is 2.6042kg and that of upgraded part is 2.203kg. Along these lines, the weight decrease is 15.39% by utilizing improved control arm. The cost sparing by utilizing streamlined lower control arm over existing control arm is 8.8%.

Do-Hyoung Kimet al. [3]In this paper its accentuations on structure of a car composite lower arm utilizing carbon-epoxy composite materials. To improve the loading grouping of the composite layer, it utilized a smaller scale hereditary calculation and researched its impacts on the exhibitions of a lower arm, for example, static/clasping load capacity and firmness. To augment the clasping load ability, we played out the structure enhancement with the straight irritation eigenvalue examination, focusing on a half weight decrease of regular steel lower arm. At last, it is discovered that composite lower arm had multiple times higher solidness and clasping quality contrasted with the regular steel lower arm while having half less weight. At that point, the static Riks strategy is utilized to research the composite overlay disappointment load dependent on the Tsai-Wu failure rule and the real buckling load of the ideally planned composite lower arm. Riks failure load investigation regarding different eigen values decided the last stacking edges, considering both composite cover disappointment and clasping disappointment. For the composite lower arm with the last plan of stacking points, the disappointment burden and firmness were seen as 2.2 occasions higher and multiple times higher (3383 kgf and 70.9 kgf/mm) than those of the steel lower arm (1500 kgf and 32.75 kgf/mm), individually, while meeting the objective weight decrease of half (2.15 kg to 1.12 kg).

MohdViqaruddinet al. [4]In this paper it presents the static examination and torsion investigation of the control arm by utilizing Radioss programming and to improve the solidness of the control arm and weight decrease of part by changing the geometrical measurement and auxiliary properties. Cross section is completed by utilizing 10 hubs tetrahedral component in Hyper Mesh and topology enhancement is done for the given structure space. The topology advancement given the possibility of ideal material design dependent on load and limit conditions. Last correlation as far as weight and segment execution outlines that basic improvement procedures are viable to deliver more excellent items at a lower cost. Right off the bat, the procedure of the auxiliary improvement includes the variety of weight from base to new model, which came about to the 40% weight decrease of the current modern part. The Control arm has additionally experienced weight decrease utilizing the material determination through the use of ALTAIR RADIOSS SOFTWARE. The outcomes got states that 41% of the weight decreases is done to the part. Henceforth, in this paper we have seen that the weight is diminished 41% through the utilization of the advanced aluminum material.

Liang Tang et al. [5]In this paper it presents the topology enhancement model including rotating appendages and bushing for topology streamlining of an aluminum CA is built up, where a swiveling appendage is improved as unbending components and the versatile properties of an elastic bushing are assessed utilizing Mooney-Rivlin constitutive law. The principle commitment of this paper is the foundation of the topology optimization model for the CA with contemplations of the elastics of rotating appendages and elastic bushings, and the technique for treating with numerous heaps in topology enhancement of CA. The topology enhancement results are contrasted and without the displaying the firmness of rotating attachments and elastic bushings. It is presumed that the elastics of swiveling appendages and bushings ought to be demonstrated in the topology advancement of a Control Arm so as to meet the prerequisites of stress, firmness, and first request characteristic frequency for the Control Arm.

3. PROBLEM STATEMENT

Chassis parts are a basic piece of a vehicle, ruling out mistake in the plan and quality the current procedure identifies with a PC supported structure examination and structure realistic showcase gadget and technique, and all the more especially, to a PC helped structure investigation of lower control arm and which is broke down and planned, along these lines meet the client necessities of LCA. This task is to advance the lower control arm by DOE FFT analyser and Impact Hammer Test by proposing reasonable material, and diminishing sheet metal thickness, to lessen the cluster creation cost and to build the quality of LCA.

4. OBJECTIVES

- To prepare CAD design of existing lower control arm using CATIA V5 software.
- Static structural analysis of automotive lower control arm using ANSYS software.
- Optimization of Automotive lower control arm.
- Testing and validation of automotive lower control arm with the help of FFT analyzer and Impact Hammer Test.
- Experimental testing of optimized design.
  Validation of experimental and numerical result of both LCA

5. METHODOLOGY

Step 1:- Initially research papers are studied to find out research gap for project then necessary parameters are studied in detail. After going through these papers, we learnt about lower control arm.

Step2:- Research gap is studied to understand new objectives for project.

Step 3: - After deciding the components, the 3 D Model and drafting will be done with the help of software.
Step 4: - The components will be manufactured and then assembled together.
Step 5: -The testing will be carried out and then the result and conclusion will be drawn.

6. CATIA MODEL OF EXITING LOWER CONTROL ARM

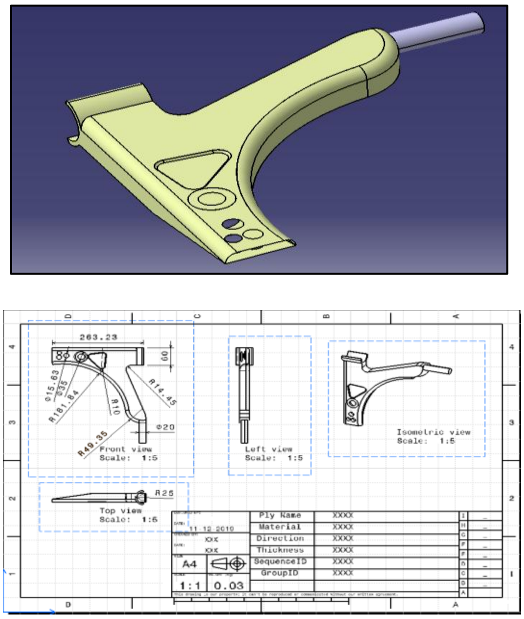
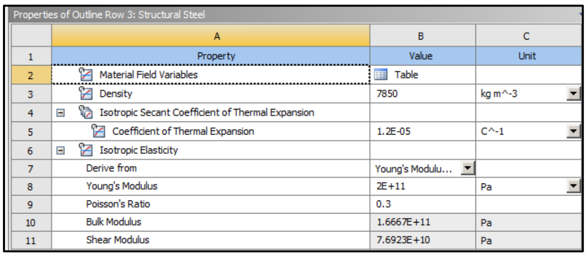


Fig.1 CATIA and drafting of lower control arm

Material Properties



Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
5	Coefficient of Thermal Expansion	1.2E-05	C^-1
6	Isotropic Elasticity		
7	Derive from	Young's Modulu...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

Table 1 Material properties

FEA ANALYSIS OF EXISTING LOWER CONTROL ARM

Geometry

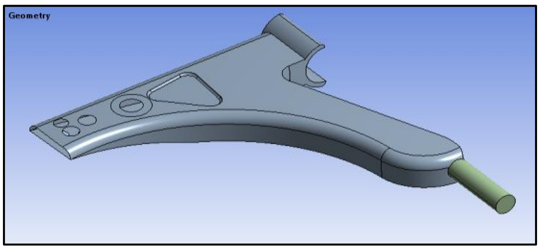
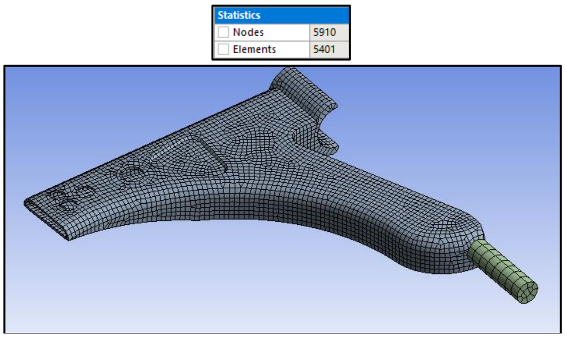


Fig.2 CATIA model imported in ANSYS

Mesh

In ANSYS meshing is performed as similar to discretization process in FEA procedure in which it breaks whole components in small elements and nodes. So, in analysis boundary condition equation are solved at this elements and nodes. ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient, multiphysics solutions. A mesh well suited for a specific analysis can be 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.



Statistics	
Nodes	5910
Elements	5401

Fig.3 Details of meshing of lower control arm

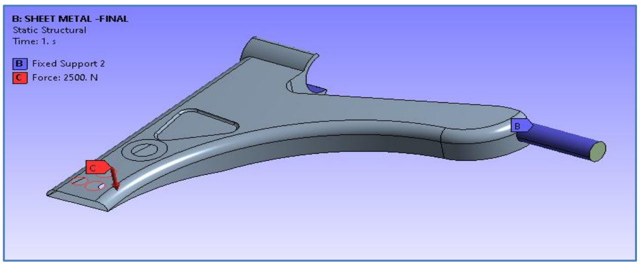


Fig.4 Boundary condition

- 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

Equivalent stress

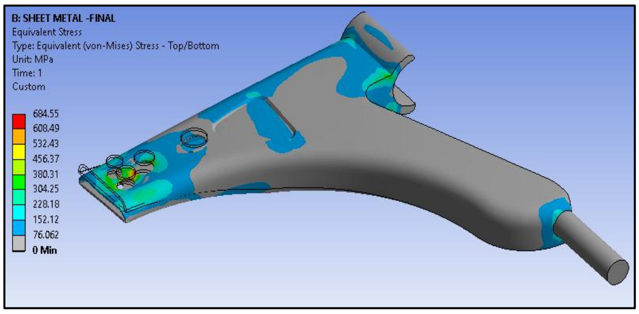


Fig. 5 Equivalent stresses

Maximum stress obtained after application of load is 684.55 MPa under existing design.

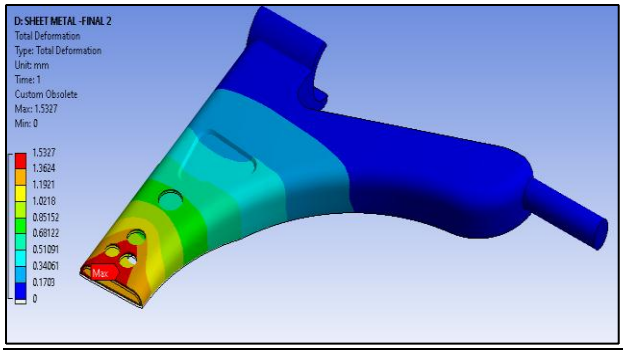
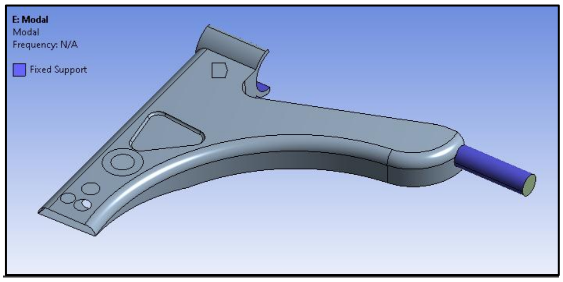


Fig.6 Total deformation results

MODAL ANALYSIS OF EXISTING LOWER CONTROL ARM



Fixed support is applied at region indicated in blue color of mounting location

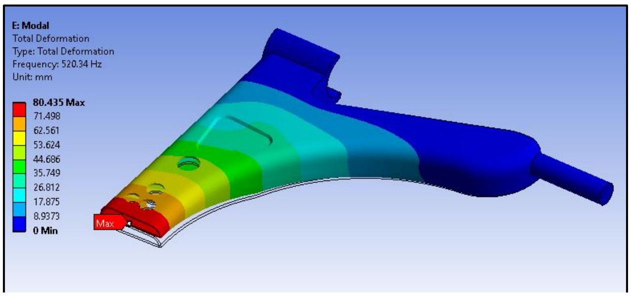


Fig. 7 Mode shape 1

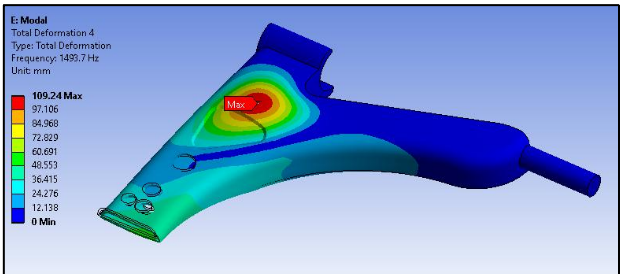


Fig. 8 Mode shape 4

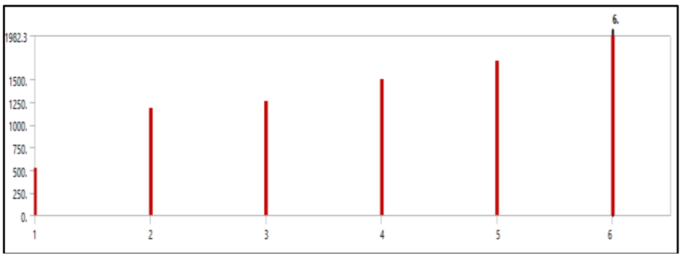
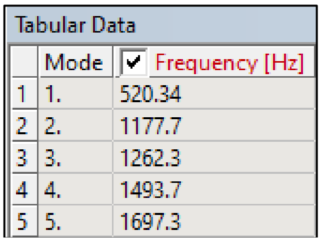


Table 2 Tabular data of mode shape frequency



Tabular Data

	Mode	☑ Frequency [Hz]
1	1.	520.34
2	2.	1177.7
3	3.	1262.3
4	4.	1493.7
5	5.	1697.3

7. MODIFIED LOWER CONTROL ARM

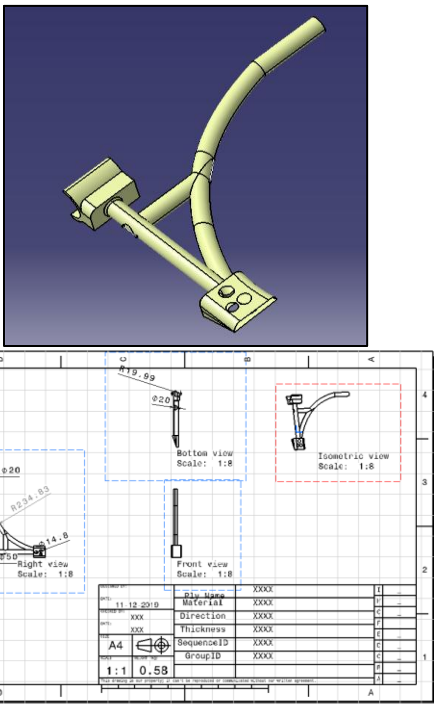
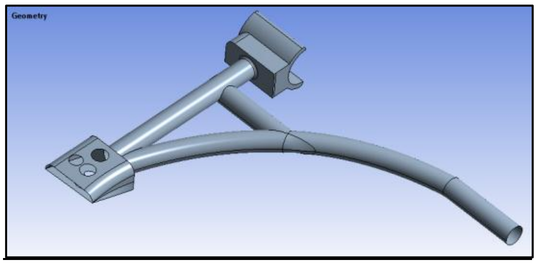
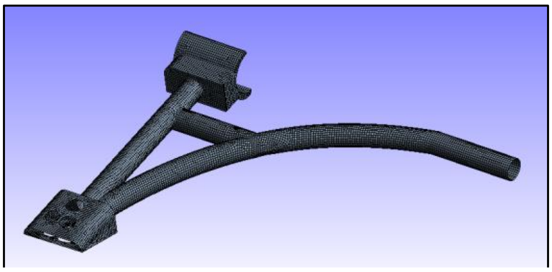


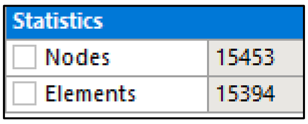
Fig. 9 CATIA and drafting of modified LCA



☐ Thickness 4. mm

Fig. 10 Modified geometry imported in ANSYS





Statistics	
☐ Nodes	15453
☐ Elements	15394

Fig. 11 Details of meshing

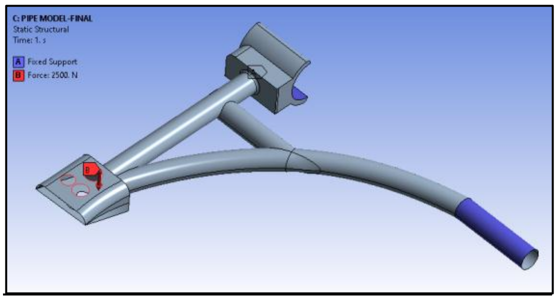


Fig. 12 Boundary condition for modified LCA

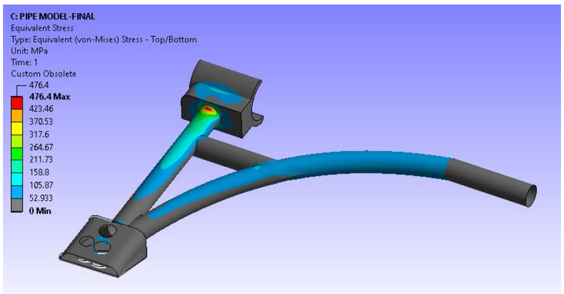


Fig. 13 Equivalent stress results

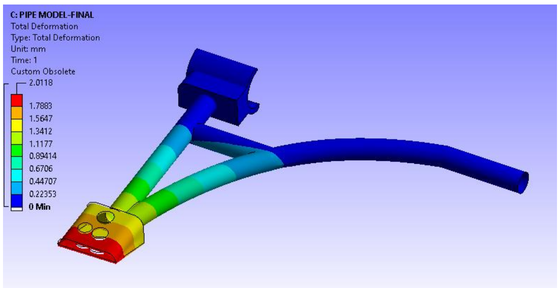


Fig. 14 Total deformation results

Maximum equivalent stress obtained after modification of design is 476 MPa which is less than existing design. So, these modified designs can be utilized for existing design.

MODAL ANALYSIS OF EXISTING LOWER CONTROL ARM

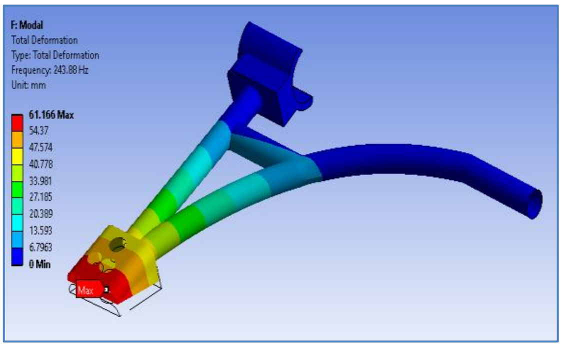


Fig. 15 mode shape 1

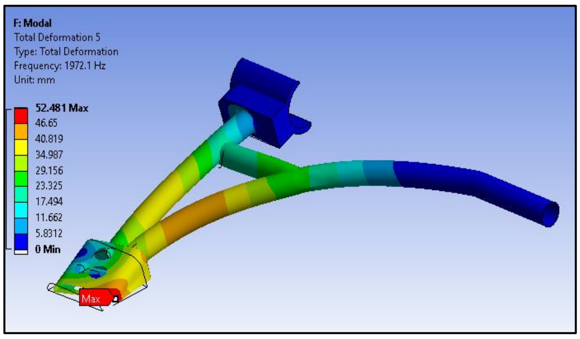
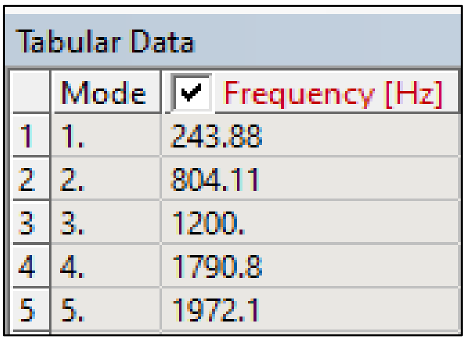


Fig. 16 mode shape 5



Tabular Data

	Mode	☑ Frequency [Hz]
1	1.	243.88
2	2.	804.11
3	3.	1200.
4	4.	1790.8
5	5.	1972.1

Table 3 frequency chart of optimized model

8. EXPERIMENTAL SETUP

A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials. An earlier name for a tensile testing machine is a tensiometer. The "universal" part of the name reflects that it can perform many standard tensile and compression tests on materials, components, and structures (in other words, that it is versatile). The set-up and usage are detailed in a test method, often published by a standards organization. This specifies the sample preparation, fixturing, gauge length (the length which is under study or observation), analysis, etc. The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the testing machine and its drive systems including any slipping of the specimen in the grips. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen.

Specification of UTM

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3 Phase , 440Volts , 50 cycle. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

9. EXPERIMENTAL TESTING FEA

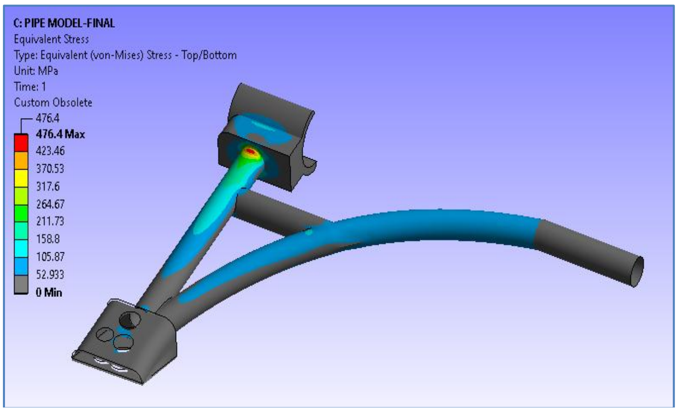


Fig. 17 Experimental equivalent stress

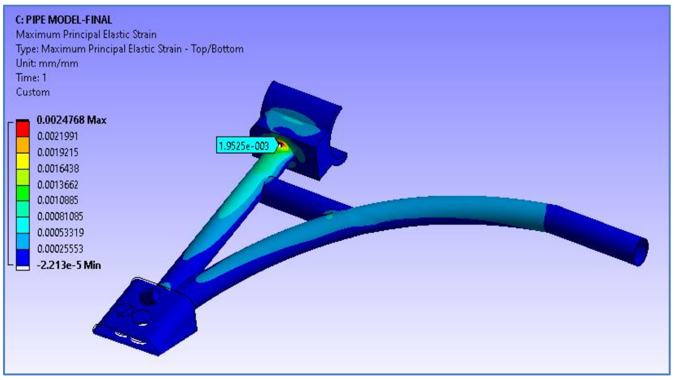


Fig. 18 Maximum elastic strain

- Strain is observed around 1952 microns using FEA.

Experimental procedure

- Fixture is manufactured according to component designed.
- Single force is applied as per FEA analysis and reanalysis is performed to determine strain by numerical and experimental testing.
- Strain gauge is applied as per FEA results to maximum strained region and during experimental testing force is applied as per numerical analysis to check the strain obtained by numerical and experimental results.
- During strain gage experiment two wires connected to strain gage is connected to micro controller through the data acquisition system and DAQ is connected to laptop. Strain gage values are displayed on laptop using DEWESOFT software.

Fig. 19 Experimental testing

Fig. 20 Experimental results

10. CONCLUSIONS

- Static analysis of lower control arm with existing and modified design has been performed to evaluate deformation and equivalent stress.
- 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.

- Modal analysis is performed to determine mode shape pattern with respective natural frequency.
- Strain measurement of 1952 microns and 1970 microns by numerical and experimental testing respectively.

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